

JOINT INSTITUTE FOR MARINE OBSERVATIONS

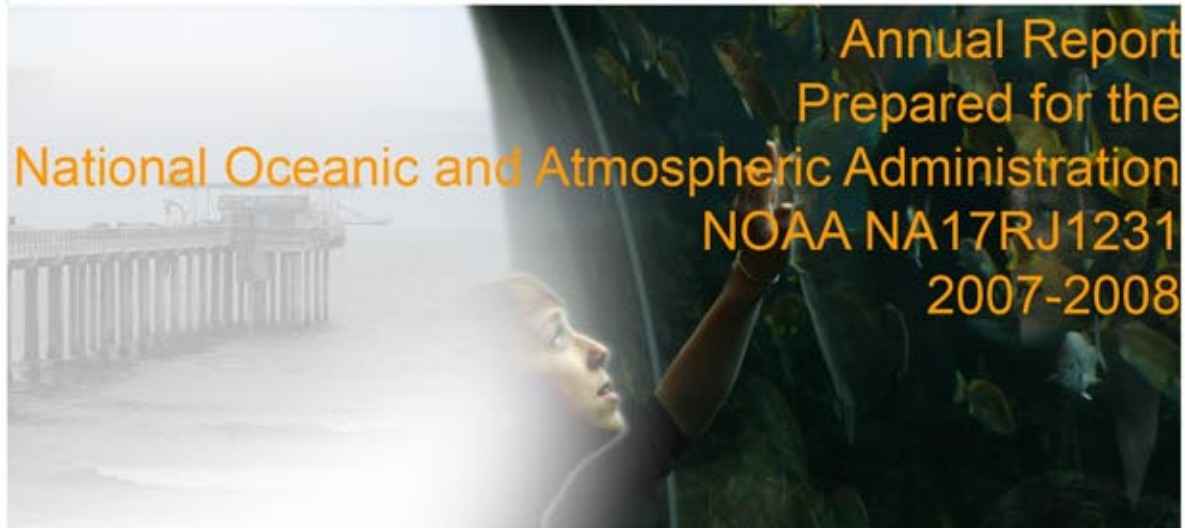
ANNUAL REPORT

2007-2008





Joint Institute for Marine Observations



Annual Report
Prepared for the
National Oceanic and Atmospheric Administration
NOAA NA17RJ1231
2007-2008



JIMO

Joint Institute for Marine Observations (JIMO)

Scripps Institution of Oceanography

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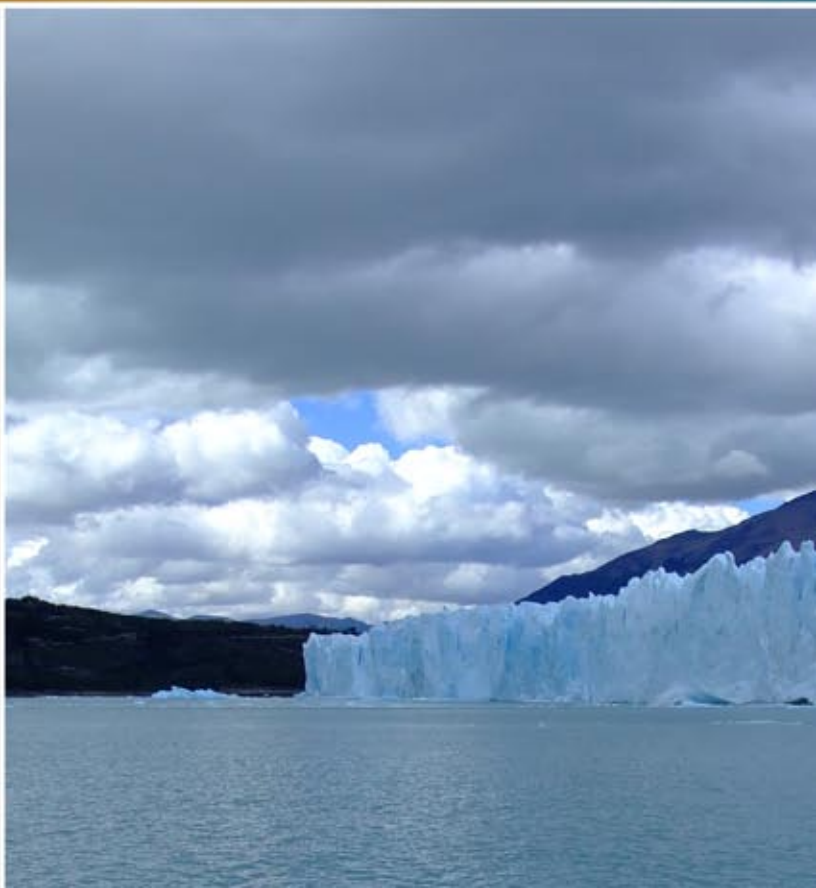
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INTRODUCTION

JIMO research and program activities for the seventh year (2007-2008) of the **National Oceanic and Atmospheric Administration** (NOAA) grant **NA17RJ1231** are outlined in this report. JIMO is affiliated with the **Scripps Institution of Oceanography** (SIO), a multi-disciplinary Institution for ocean, climate, earth and environmental research as part of the University of California, San Diego (UCSD) campus and greater University of California (UC) system. Included in this report are the individual projects, activities and accomplishments of JIMO researchers and partners at SIO and UC, as well as other collaborating organizations associated with JIMO.

JIMO's purpose is to facilitate and enhance research cooperation between NOAA entities and SIO, in particular, and the University of California (UC), in general, pertinent to the mission of NOAA. Initially, this mainly involved fostering existing NOAA-funded projects by SIO staff. As collaboration expanded and opportunities grew, JIMO undertook facilitation of the work of many scientists outside SIO and began to develop new programs and, at the same time, took advantage of its position within UC to employ the talents of an expanded constituency. New this year, JIMO initiated its first postdoctoral scholar program. The recruitment process resulted in the hiring of two candidates in the 2008-2009 period. Other JIMO fellows chose to independently support several other candidates not chosen by the JIMO program as a result of this recruitment effort.

During the July 1, 2007 to June 30, 2008 period, the NOAA research entities listed below were engaged with SIO as part of JIMO in marine, atmospheric and climate research, education and outreach efforts, data collection, and collaborative activities:

- Office of Oceanic and Atmospheric Research (OAR)
- Climate Program Office (CPO)
- Atlantic Oceanographic and Meteorological Laboratory (AOML)
- Pacific Marine Environmental Laboratory (PMEL)
- National Center for Atmospheric Research (NCAR)
- National Center for Environmental Prediction (NCEP)
- National Data Buoy Center (NDBC)
- National Marine Fisheries Service (NMFS)
- National Marine Sanctuary Program (NMSP)
- US Antarctic Marine Living Resources (AMLR)
- Earth System Research Laboratory (ESRL)
- Environmental Research Laboratory (ERL)
- Office of Ocean Exploration (OE)
- Pacific Fisheries Environmental Laboratory (PFEL)
- Florida Keys National Marine Sanctuary (FKNMS)
- Coastal Service Center (CSC)
- National Oceanic Data Center (NODC)
- National Geodetic Survey (NGS)



DIRECTOR'S LETTER

This has been a very productive and exciting year for JIMO, marking important milestones, while establishing new programs and making new discoveries that attest to the value of the long collaboration between NOAA and Scripps Institution of Oceanography, in recent decades through JIMO. While the pages of this report provide details of the many JIMO programs and their support of NOAA's mission, a few highlights will serve to demonstrate the breadth of JIMO's work and the scientific benefit of sustained observations in better understanding all aspects of the marine and atmospheric environments, especially their roles in climate and ecological variability.

In December NOAA and SIO jointly sponsored a conference celebrating the 50th anniversary of the continuous measurement of the concentration of CO₂ at the Moana Loa Observatory. Started and sustained by Charles David Keeling, it led to the iconic "Keeling Curve," which has become one of the benchmarks for climate change research and for proposals to limit green house gas emissions.

JIMO Fellows, drawing on the 59-year record of the California Cooperative Fisheries Investigation (CalCOFI), have made important discoveries correlating fluctuations in the sardine fishery to the climatology of the upwelling winds. Other studies using the CalCOFI data have demonstrated the potential destabilizing impact of commercial fishing in the context of nonlinear dynamical principles.

Using data from two decades of the global surface drifter programs, former JIMO Director Peter Niiler, and colleagues have demonstrated the ubiquity of linear fine-scale structures in ocean current systems. The coherence of these features presents a challenge for ocean modelers.

This year marked the start of full operational capability of the Argo array of ocean profiling floats, which has already had a profound impact on our ability to better understand the ocean's role in climate. For his scientific contributions, and for leading the development and implementation of the Argo array, Dean Roemmich was awarded the Sverdrup Gold Medal of the American Meteorological Society.

Other JIMO Fellows to win awards and prizes include JIMO climate and atmospheric scientist, V. "Ram" Ramanathan, who won the Zayed International Prize for the Environment from the United Arab Emirates, recognizing his "major pioneering contributions in the field of environment and sustainable development." JIMO marine ecologist, Jeremy Jackson, received the 11th annual Roger Tory Peterson Medal of the Harvard Museum of Natural History.

This year also marks the passing in June of our colleague, John Roads, who led the Experimental Climate Prediction Center at SIO. John's skills in climate prediction will be long remembered and sorely missed by his colleagues around the world.

I hope you enjoy reading more about JIMO and what we do. Much of it would not have been possible without our "front office," Anne Footer, Rose Keuler, Karim Hussein and Garrett Eaton, who provide excellent administrative support for the JIMO Fellows; getting proposals, reports, and especially annual reports, out the door.

W. Kendall "Ken" Melville
JIMO Director



ORGANIZATION

Mission Statement

JIMO's mission is to foster and enrich a center of excellence in which scientific research, education and public outreach are joined to strengthen and improve our understanding of global ocean, climate and earth sciences through individual and collaborative research.

Vision Statement

JIMO shares the fundamental mission and goals of NOAA research and strives to achieve several objectives based on the unique resources and character of the Scripps Institution of Oceanography (SIO), in particular, and University of California (UC), in general: (1) to foster collaborative research between NOAA and UC scientists; (2) to facilitate participation of UC and other academic scientists in NOAA programs; and (3) to use the educational strength of UC both to train students for productive work in environmental activities and to educate the citizenry about the intellectual excitement and importance of studying and managing our environment.

The current Memorandum of Understanding (MOU) between NOAA and SIO that outlines the purpose, goals and structure of JIMO is the original established in 1991. In this agreement, plans for an Executive Board and Council were set, but a Council was never appointed. As this MOU marked the first Joint Institute at SIO, the anticipated role of a Council was filled by natural interactions of JIMO members already immersed in the highly collaborative community existing at SIO. In practice, the need for scientific guidance or leadership was filled by open communication between JIMO Investigators (AKA "Fellows") and the JIMO Director, as well as other UC/SIO researchers or NOAA officials, on an "as needed" or case-specific basis. The same held true for the Executive Board, until 2005. In preparing for a programmatic and scientific review by NOAA in May 2005, JIMO sought leadership and advice from outside SIO. The Executive Board met at SIO on April 5, 2005 and this meeting yielded valuable advice that contributed to an overall positive review of the JIMO program by NOAA officials and the Review Panel. Reinforced by the Review Panel's recommendations, JIMO is committed to respond to its escalating growth with accelerated efforts to establish a governing body and strategic plan for the future. The role of the Executive Board, in particular, will become increasingly important, as JIMO prepares to re compete its NOAA Cooperative Institute award in Fall 2009. Throughout his first year as JIMO Director, Dr. Ken Melville met with his Council of Fellow, which yielded productive discussions and recommendations for JIMO's direction. In June 2008, Dr. Melville made a site visit to UC Santa Cruz to discuss JIMO research with NOAA staff and UC faculty at the NMFS Santa Cruz facility. Also, this year saw the nomination of a new Executive Board, whose members are listed below.

JIMO Executive Board Roster

Director:

W. Kendall "Ken" Melville is a professor and Deputy Director for Research at Scripps Institution of Oceanography, University of California, San Diego. His research interests are in the areas of air-sea interaction and nonlinear surface and internal wave phenomena. His work encompasses the development of novel techniques for field observations along with supporting theoretical and modeling components. Recent work has focused on air-sea interaction in high winds and hurricanes. He has Bachelor and Master's degrees in science and engineering from Sydney University and a Ph.D. from Southampton University.



Board Members:

John Orcutt is a Professor at Scripps Institution of Oceanography and Director of the UCSD Center for Earth Observations & Applications. He graduated from Annapolis (1966) and received his Ph.D. in Earth Sciences from Scripps (1976). He is President of the American Geophysical Union (AGU) and was a member of the Science Advisory Panel to the Ocean Policy Commission. He was elected to the American Philosophical Society in 2002. His research interests are seismology and the use of information technology in integrating sensor networks; he has published more than 150 peer-reviewed papers.

Phillip Arkin is Director of the Cooperative Institute for Climate Studies (CICS) at the Earth System Science Interdisciplinary Center (ESSIC) of the University of Maryland, where he also serves as Deputy Director and Senior Research Scientist. He conducts research into the observation and analysis of precipitation and other aspects of the hydrological cycle of the global climate system. Until January 2002, he served as Program Manager for Climate Dynamics and Experimental Prediction in the Office of Global Programs at NOAA, where he managed the Applied Research Centers that provide the research and development that enable NOAA to provide better climate forecasts. From 1998-2000, he served as the Deputy Director of the International Research Institute for Climate Prediction (IRI) at Columbia University. He has spent the last 25 years working at NOAA as a research scientist and administrator in various parts of the climate community, including the Climate Prediction Center, the Office of Global Programs and the National Centers for Environmental Prediction. He invented the GOES Precipitation Index, a method for estimating rainfall from geostationary satellite observations, and led the Global Precipitation Climatology Project from 1985-1994. His B.S. in mathematics and M.S. and Ph.D. in meteorology are from the University of Maryland. Dr. Arkin has published more than 50 refereed papers in scientific journals, 22 atlases and chapters in books, and has had more than 100 non-refereed publications. He has served as a member of many national and international scientific panels and has presented invited papers at more than 100 workshops and scientific meetings.

W. John Gould is currently serving as the International ARGO Project Director, as well as a Frohlich Fellow at CSIRO in Hobart, Australia. In addition to ARGO, Dr. Gould served as the appointed Director at both the International CLIVAR Project Office and the WOCE International Project Office. He possesses over 30 years of experience as an observational oceanographer and science project leader and over 20 years of experience managing science projects at a national and international level. He has served as chief scientist on more than 20 deep-sea oceanographic cruises. Receiving both his M.S. and Ph.D. in Oceanography at the University College of North Wales, Bangor, Dr. Gould has received numerous awards and been published in dozens of significant, refereed publications during his career. His primary research interests include: The Role of the Oceans in Climate, North Atlantic Circulation, use of neutrally buoyant floats to explore ocean circulation, underwater acoustics, oceanographic and climate data management, and public understanding of science.

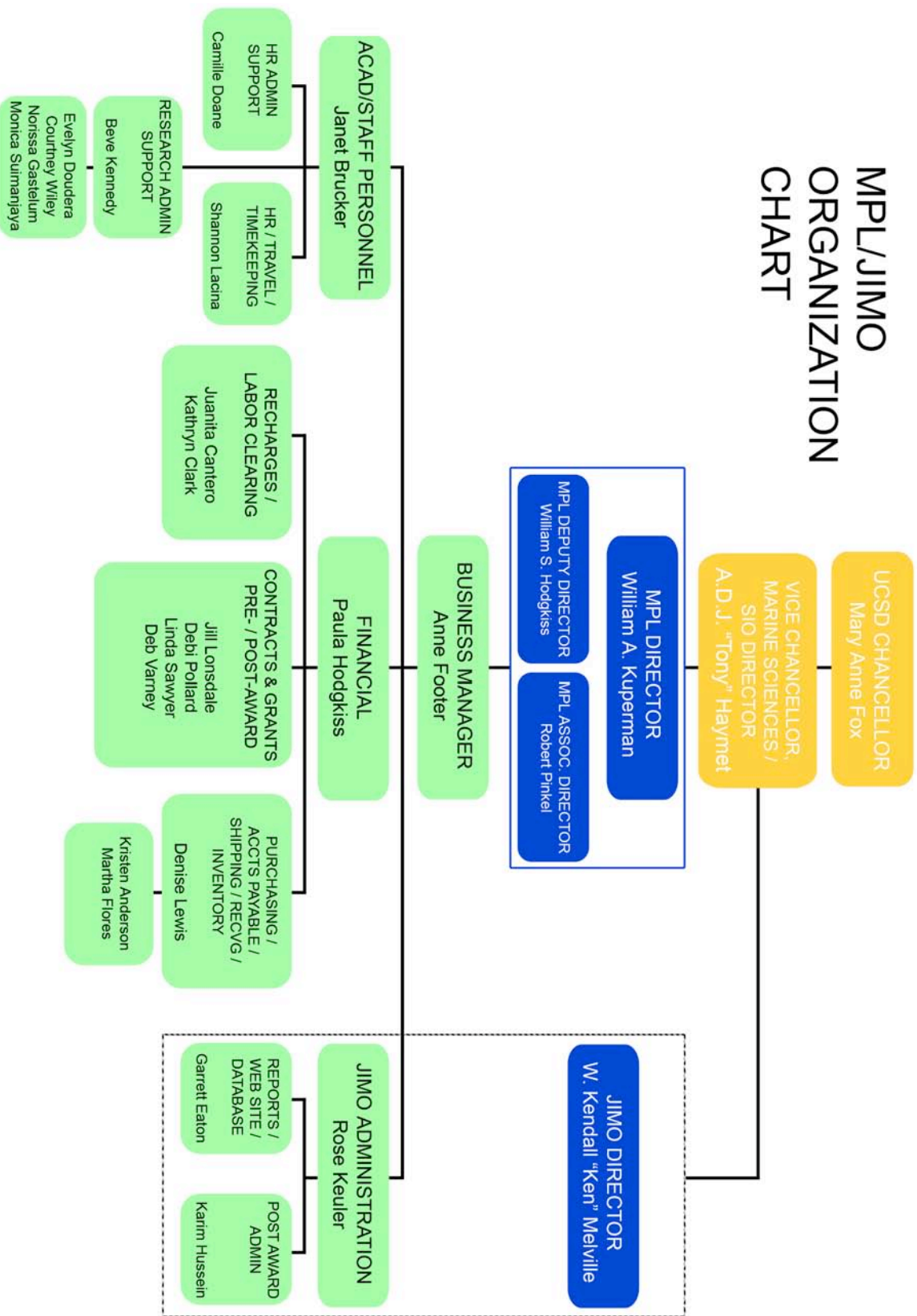
Kenneth Mooney has been Deputy Director of NOAA's Office of Global Programs (OGP) since 1994. Before that, he served as Program Manager and then Director of the U.S. TOGA Project Office. He is an experienced Oceanographer, working for both the NOAA Engineering Support Office and U.S. Coast Guard Oceanographic Unit. Dr. Mooney received his B.S. and M.S. in Physics from the Rensselaer Polytechnic Institute and University of Maryland, respectively, and his Ph.D. in Oceanography was conferred by the University of Rhode Island in 1977.

David B. Zilkoski has been employed by NOAA for over 30 years, serving currently as Director of the National Geodetic Survey. He received a B.S. degree in Forest Engineering from the College of Environmental Science and Forestry at Syracuse University in 1974 and a M.S. degree in geodetic science from the Ohio State University in 1979. He has authored a number of publications on coastal subsidence, surveying and vertical datum. Mr. Zilkoski is also a past President of the American Association for Geodetic Surveying, a member of the American Geophysical Union, Maryland Society of Surveyors, and a fellow of the American Congress on Surveying and Mapping and the International Association of Geodesy.

William Fox, current Director of the NOAA Southwest Fisheries Science Center, has a long history of exemplary leadership and service with NOAA. Since 1990, he has served as Director of NOAA Fisheries, the Office of Science and Technology, and Office of Protected Resources. Prior, Dr. Fox was a professor of marine biology and fisheries and Director of the Cooperative Institute for Marine and Atmospheric Studies at the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Dr. Fox has authored or co-authored over 60 scientific publications. He is a member of the American Fisheries Society, a Fellow of the American Institute of Fishery Research Biologists and Sigma Xi—the Research Society. His formal education includes a B.S. in zoology (1967) and an M.S. in marine science (1970) from the University of Miami and a Ph.D. in fishery science (1972) from the University of Washington.



MPL/JIMO ORGANIZATION CHART





JIMO Employee Summary (July 1, 2007 – June 30, 2008)

Personnel Supported by NOAA/JIMO Funding				
Category	Number	B.S. / B.A.	M.S.	Ph.D.
Associate Director	1			1
Professor	4			4
Academic Researcher	6			6
Academic Specialist	5			5
Sr. Museum Scientist	1	1		
Project Scientist	4			3
Postdoctoral Fellow	5			5
Sr. Statistician	1			1
Programmer/Analyst	12	9	2	1
Staff Research Assoc/Asst	9	2	5	
Laboratory Asst	4	4		
Development Engineer	2	1	1	
Marine Technician	13	9	2	
Administrative Analyst	1	1	1	
Administrative Specialist	2	1		1
Total (≥ 50% support)	56	12	10	27
Undergraduate Students	21			
Graduate Students	16			
Employees that receive < 50% NOAA Funding (not including students)	84	21	15	18
Located at Lab (include name of lab)	9	NOAA Santa Cruz laboratory		
Obtained NOAA employment within the last year	1	1 SWFSC		
Sub-awards				
Postdoctoral Fellow	5	1 NWFSC		
Graduate Students	9			



JIMO Fellows Roster (July 1, 2007 – June 30, 2008)

Peter Adams (UC Santa Cruz)	Peter Lonsdale (SIO)
Bruce Appelgate (SIO)	Marc Mangel (UC Santa Cruz)
Timothy Barnett (SIO)	Baldo Marinovic (UC Santa Cruz)
Yehuda Bock (SIO)	John McGowan (SIO)
Daniel Cayan (SIO)	Peter Niiler (SIO)
David Checkley (SIO)	Mark Ohman (SIO)
Bruce Cornuelle (SIO)	John Orcutt (SIO)
Russ Davis (SIO)	Cheryl Peach (SIO)
Andrew Dickson (SIO)	V. Ramanathan (SIO)
Peng Fang (SIO)	John Roads (SIO)
Falk Feddersen (SIO)	Dean Roemmich (SIO)
Ralf Goericke (SIO)	Daniel Rudnick (SIO)
Robert Guza (SIO)	Lynn Russell (SIO)
John Hildebrand (SIO)	Uwe Send (SIO)
Osmund Holm-Hansen (SIO)	George Sugihara (SIO)
Jeremy Jackson (SIO)	Eric Terrill (SIO)
Masao Kanamitsu (SIO)	Frank Vernon (SIO)
Ralph Keeling (SIO)	James Wilen (UC Davis)
J. Anthony Koslow (SIO)	Guang Zhang (SIO)
Lisa Levin (SIO)	

In memoriam John Roads (1950 – 2008)
Scripps Professor • JIMO Fellow • Climate Forecast Innovator







RESEARCH TASKS AND THEMES

Research Tasks

Under the Joint Institutes' cooperative agreement, five tasks are outlined by JIMO and agreed upon by NOAA, allowing JIMO to group and account for research more easily. The tasks are identified as follows:

Task 1. Administration

Task 1.1 funding is for administration of the Institute and includes support for the JIMO Director's office and minimal support for the staff. It includes costs associated with annual scientific meetings that are deemed important for the JIMO Director to attend, workshops sponsored by JIMO, web-site development and maintenance, funding for the Joint Institute Director's and administrative board meetings.

Task 1.2 is to support the postdoctoral fellows and graduate students, as well as provide a visiting fellows program. It is intended to be a very visible mission of this Institute. Funding will be provided based on merits of the researchers and applicability of interdisciplinary specialties that can be utilized across various JIMO projects.

Task 2. Joint NOAA Laboratory/JIMO Programs

The collaborative proposal has NOAA and UC/SIO working together jointly on research themes. These proposals are divided by theme and include all research associated with funding including the funding of salaries, benefits, as well as instrumentation and computer time.

Task 3. Individual Science Projects

A cooperative research proposal is one which is specific to the JIMO theme areas, but is submitted by individual scientists of JIMO. The distinction here is that there is a loosely bound tie between individuals working on similar themes or topics. It is also seen that this may be a mechanism for developing collaborative proposals in the future, as well as encouraging new areas of research to develop. These proposals are divided by theme and include all research associated funding including the funding of salaries, benefits, and instrumentation and computer time.

Task 4. JIMO Cooperative Research Programs with Other Research Institutions

In support of NOAA's Mission and Strategic Plan, JIMO's Task 4 was developed to strengthen and coordinate a University of California multi-campus environment by establishing a regional concept for marine and atmospheric sciences. Proposals would include research conducted at other University of California campuses, such as Santa Cruz, Santa Barbara and Davis, as well as other academic institutions and non-profit research institutions, when appropriate, in support of JIMO and NOAA research missions, and in meeting NOAA's strategic goal of environmental stewardship. These proposals will include a program development cost (PDC) that will support the Visiting/Postdoctoral Fellows program at JIMO/SIO (Task 1.2).

Task 5. JIMO Research Infrastructure Proposals

Because proposals relevant to JIMO will be using a variety of observation platforms in order to carry out the research objectives, an infrastructure task by theme area was defined, which includes proposals for platform and specialized research facilities. We anticipate that a number of other agencies will be partners in support of the platform infrastructure.

Research Themes

Four thematic areas form the basis for research performed in partnership with NOAA. Each of these areas are relevant to the NOAA mission elements, particularly those of environmental assessment and prediction and environmental stewardship.

A. Climate and Coastal Observations, Analysis and Prediction Research

The primary goals for this research theme are to understand the remote forcing functions that control fundamental ocean and atmosphere processes and to utilize this knowledge for prediction. For JIMO the



basis of interest is primarily the Pacific, although other areas may be studied as a model or to put the Pacific information in context (e.g., Indian, Arctic). These thrust areas include the following:

Ocean observations will utilize many of the in-place observation systems such as the TAO/TRITON array, drifters, floats and satellite remote sensing to provide information for models on climate prediction at the ENSO to decadal space and time scales. Defining the ocean's role in governing the climate necessitates the expansion of large-scale, long-term field observation and modeling efforts begun over the past few years in the Pacific to the global system. A networking of these programs in the UC to NOAA research projects is essential to the success of the effort. Deep ocean circulation constitutes another emphasis of this theme area that stresses the fundamental processes governing geochemical pathways. Deep ocean characterization, including deep-water formation and tracking that uses state-of-the-art floats and moorings, as well as unique observations and monitoring techniques, such as chemical or geochemical tracers for signature analysis. In addition, proxy data is used in providing the past climate variability.

Climate prediction and modeling are concerned with the development and evaluation of a wide range of climate models. Of interest are global atmospheric models, regional atmospheric models, global and basin ocean models, and land surface models concerned with surface hydrology and fire danger. The JIMO goal is to eventually develop coupled atmosphere, ocean and land models that provide greater predictability than is possible with current uncoupled models of these processes. Defining the limits of predictability for these systems requires extensive computational resources and collaborations with NOAA centers that are engaged in similar research efforts.

Coastal ocean assessment and forecasting seeks to measure and define the basic processes in the near-shore ocean (eddies, upwelling, currents) and atmosphere (fog, inversions, UV). Research is required to characterize the feedbacks between the coastal ocean and atmosphere and to assess the historical variability. The ultimate goal is to be able to perform short-term predictive modeling for such areas as natural hazards (oil spill), navigation and commercial recreation and the recruitment of pelagic stocks. Consideration must be given to mesoscale to small-scale processes and temporal scales of hours to decadal. The 70-year, daily SIO pier data and shore stations measurements, in situ moorings, stationary platforms, as well as aircraft and other remote sensing observations will be used to generate the necessary scientific data.

Atmosphere and ocean/atmosphere exchange will continue and strengthen research of mutual interest to SIO and NOAA scientists. These studies include: "teleconnections" and other large-scale meteorological phenomena; air-sea physical and chemical exchange processes; and global distributions and trends of climate-forcing due to anthropogenic and biogenic atmospheric trace gases and aerosols.

Biogeochemical cycles need to be further defined for their implications for global climate change. These include ocean, atmospheric and terrestrial components of the carbon cycle, oxygen cycle, UV chemistry and trace metals among others. In addition, proxy data such as ice cores will be used to measure a wide array of paleo-climatologically important physical and chemical parameters such as the CO₂ content and isotopic composition of air recovered from bubbles trapped within the ice.

B. Biological Systems Research

The population dynamics and physiological ecology of marine ecosystems is a complex research question, which involves finely tuned long-term observation programs. Process oriented research at the system and individual level lead to the fundamental understanding of the physiology and life cycle dynamics of important species. This theme area includes the following four thrust areas:

Fisheries research analyzes long-term trends of ecosystems and fisheries using databases such as the CalCOFI program, examines the schooling and behavior of selected species, develops new methods of stock assessment, and forecasts and investigates the effects of fishing activities on the environment. Food chain dynamics is of particular interest in the success of larval populations. Basic studies on the physiology and behavior of such species as sharks are of particular interest. Paleo-oceanographic techniques for the reconstruction of past distributions and abundances are necessary to help decipher the natural variability of the selected commercially important species.

Marine ecosystem monitoring and forecasting examines the distribution and abundance of organisms at all levels of the food chain in relation to their environment, primarily the physical and chemical structure. Ocean currents as transport routes, episodic events as introduction mechanisms, migration routes and impact of



climate change on species distributions is featured. Patchiness in the vertical as well as in the horizontal due to mesoscale and small-scale structure is a defined research topic.

Protected species dynamics focuses upon the refinement of acoustic sensing and tagging methods, the study of population dynamics, habitat utilization, foraging habitats and diving physiology of marine mammals. In addition, the impact of anthropogenic sound on the migration routes and behavior of these mammals is a study area necessitated by the Marine Mammal Protection Act and the increase of anthropogenic activity such as shipping, drilling and general development of the near shore zone.

Protected areas and reef systems ecology seeks to do research aimed at protecting marine habitats from anthropogenic change. Reef habitats in particular may harbor clues to past changes in climate in their physical structure. These sensitive systems harbor a diverse community and can represent a historical record of past climate events. In many cases, these habitats are threatened and in need of mitigation.

C. Research in Extreme Environments

A third theme area for the JIMO is centered on research in extreme environments. In all of the following cases, research includes the development of rugged sensors, platforms and data transmission devices to perform under adverse conditions. The “adverse conditions” range from ice to high pressure, high temperatures, fog, hurricanes, sulfur pools and anoxia to name a few. The theme area is divided into four major thrusts:

Sea-floor processes emphasize the characterization of unexplored environments and subsequent process definition in these newly described habitats. Hydrothermal vent processes continue to be an area of interest for biologists, chemists and geologists. The physiology and physiological ecology of these organisms such as extremophiles and sulfur bacteria are of interest. Vent chemistry and heat transfers into abyssal waters are areas of potential study. Ridge processes and associated crustal dynamics constitute a significant fraction of the proposed research. Methods for the better characterization of these processes or for shelf topography of the seafloor are included.

High-latitude research defines the functional dynamics between Antarctic krill populations, their environment and their predators use bioacoustic and conventional technologies to acquire data for input into pelagic ecosystem models. UV radiation and ozone abundance monitoring and modeling and prediction of health effects will be a major research topic in this thrust area. Cycles and controls of ocean production in high latitudes extending into the southern ocean and characterization of seasonal circulation patterns in the Arctic and Antarctic are included in this topic area.

Strongly forced systems studies focuses on monsoonal dynamics and variability, hurricane prediction and observations including tracking and modeling, and research in hazard impacted areas.

Toxic environment research takes place at the limits of biological survival. Anoxic waters, sulfur pools, and heavy metal contaminated sediments present difficult regions for measurement. Most of the extreme conditions are due to chemical or geochemical processes causing noxious conditions.

D. R&D on Observation Systems

The fourth theme area for research is unique in its cross cutting nature. Observation system development ensures that there is state-of-the-art research and development efforts brought to bear on scientific problems. Platforms and instrumentation re-engineering, observing system reconfiguration, and data merging and display techniques modification take place here. This is the engineering component of a smoothly operating research effort.

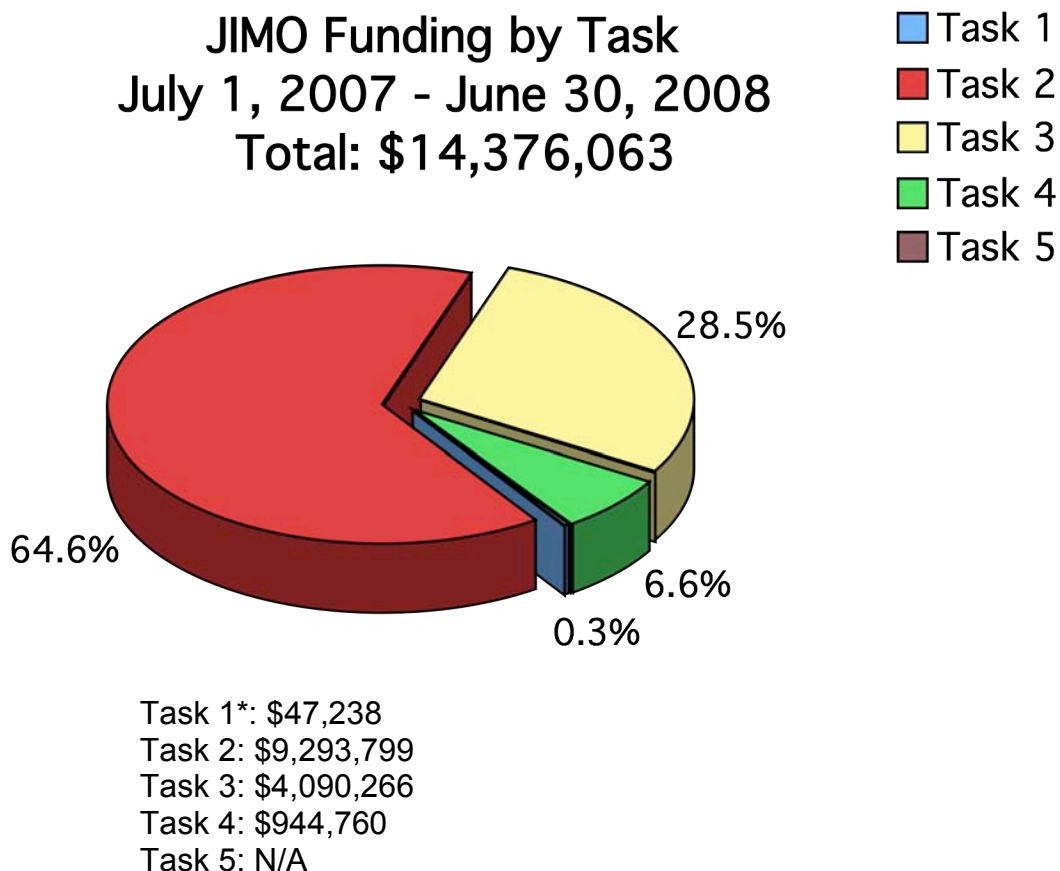
Extreme technology development focuses on rough weather deployable mooring, low threshold detection optical/chemical sensors, high pressure/heat tolerant probes, optic/acoustic nets/pens for stock assessment, queryable (pull) and push communications, minimal/self tending arrays, non-fouling chemical sensors, and aircraft deployable sensors/drifters/buoys. Improved ROVs and submersibles are among the technologies that need to be developed, refined or redesigned. Acquiring enabling technologies and platforms such as the potential addition of new SIO submersibles will significantly expand the research capabilities of the JIMO.



Systems engineering evaluation allows a probing look at the optimal design at the observation system as a system rather than a sum of the components. The goal is to evaluate the existing observing systems and optimize the system at all levels including sensor, instrumentation, platform and sampling design and to reassess the systems architecture at various intervals. Such an ongoing in-depth look at observing systems will ensure the evolution of these systems as state of the art science developments.

Information systems management is conducted in close collaboration with the NOAA units that have direct responsibility for this function and is consistent with US Ocean Data Management and Communications standards. Excellent examples, involving NWS' NDBC, build upon previously funded NSF programs including ROADNet (Real-time Observatory, Applications, and Data management Network), HPWREN (High Performance Wireless Research and Education Network), OptIPuter (Optical IP computer) and LOOKING (Laboratory for Ocean Observatory Knowledge and Information Grid) as well as major California programs especially COCOMP. Quality assurance and control of data as well as the dissemination of that data to scientific users in near-real-time is a critical function.

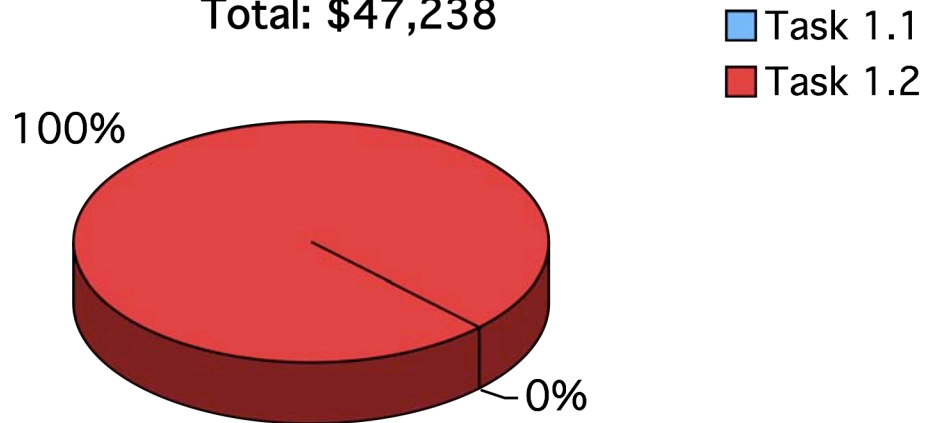
Systems modeling and simulation is an essential part of the information transfer of the research. Here the data are presented to give the most information to the potential user. The scientific models may be coupled with socio-economic or development models for use in policy making. The appropriate simulation, visualization and web-based techniques important for operations and research also help in the dissemination of the data for educational purposes to the public or K-12 level.



* See **JIMO Task 1 Funding** graph for break down of 1.1 and 1.2 funding

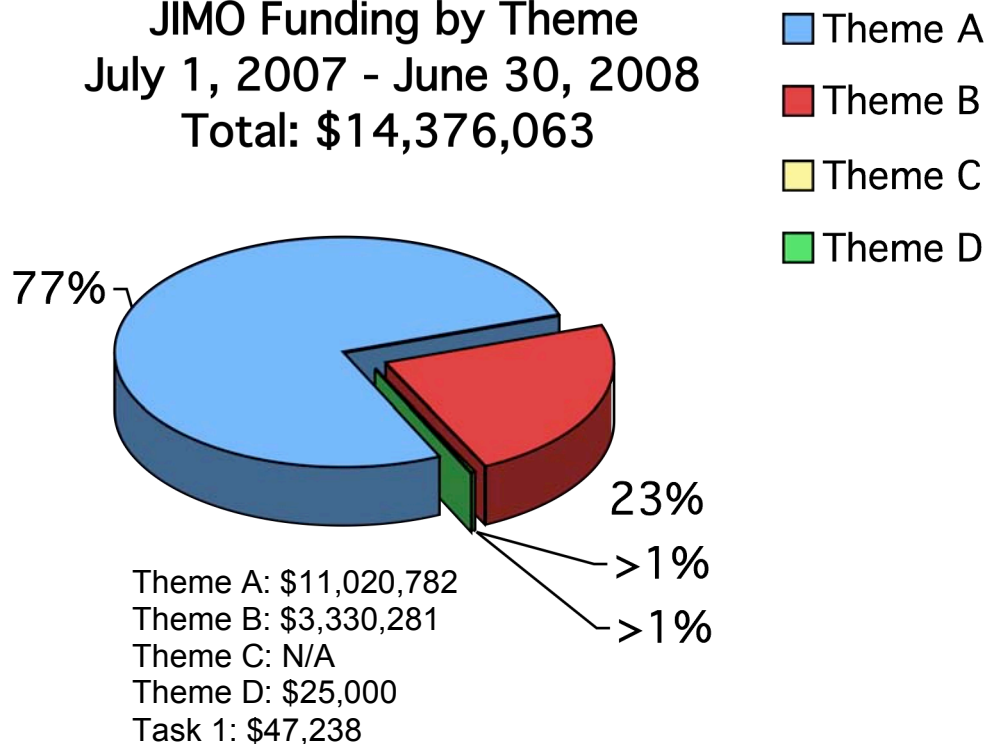


JIMO Task 1 Awarded Funding
July 1, 2007 - June 30, 2008
Total: \$47,238



Task 1.1: N/A - Task 1.1 funding pre-awarded in FY06-07
Task 1.2: \$47,238

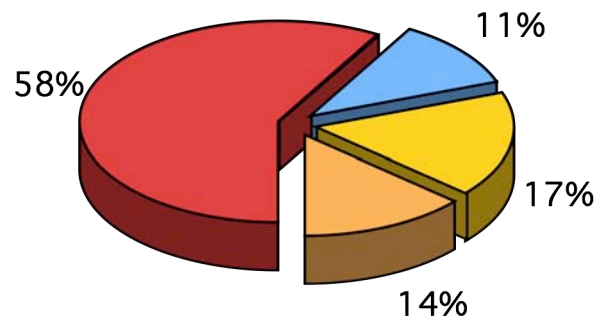
JIMO Funding by Theme
July 1, 2007 - June 30, 2008
Total: \$14,376,063





TASK 1.1	Reporting Period: July 1, 2007 – June 30, 2008	
	Awarded	Expensed
Administrative Salaries	-	\$ 21,502
Supplies	-	\$ 4,114
Travel	-	\$ 6,234
Indirect Costs	-	\$ 5,047
Total	*Task 1.1 funding pre-awarded in FY06-07	\$ 36,897

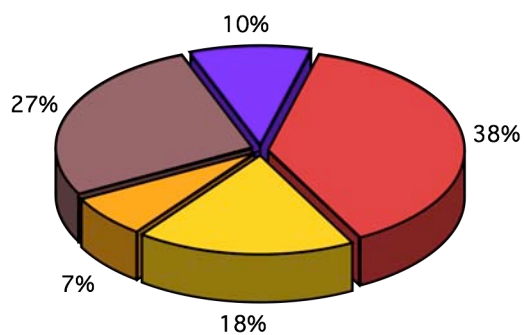
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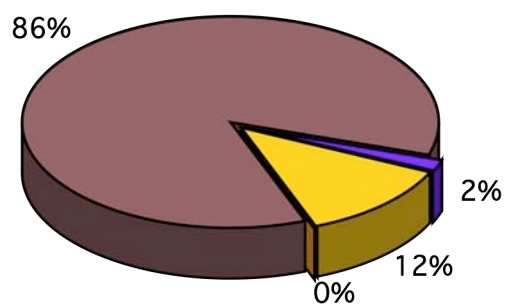


TASK 1.2	Reporting Period: July 1, 2007 – June 30, 2008	
	Awarded	Expensed
Salaries	\$ 17,942	-
Supplies	\$ 8,570	\$ 865
Travel	\$ 3,304	-
Tuition Remission	\$ 12,654	\$ 6,110
Indirect Costs	\$ 4,768	\$ 139
Total	\$ 47,238	\$ 7,114

AWARDED



EXPENSED







RESEARCH HIGHLIGHTS

JIMO research activities are categorized by the following themes:

- A. Climate and Coastal Observations, Analysis and Prediction Research
- B. Biological Systems Research
- C. Research in Extreme Environments
- D. R & D on Observations Systems

Research highlights, or Executive Summaries, of the most recent individual research projects are summarized in the tables below and are more fully developed in the body of this report.

A. Climate and Coastal Observations, Analysis and Prediction Research

Consortium on the Ocean's Role in Climate (CORC II)
[Russ Davis, SIO]

- Completed sixteen years of HRX sampling (1992 – 2008) spanning the tropical/subtropical boundary of the North Pacific Ocean, eastward limb of the subtropical South Pacific, revealing annual and interannual variability in gyre-scale circulation and in the northward transport of heat and freshwater by ocean currents
- Analyzed drifter trajectories in the marginal seas of the western Pacific that showed strong coherent flows related to the local wind regimes, including seasonal variation in the East China Sea driven by the Asian monsoon

Consortium on the Ocean's Role in Climate (CORC III): Integrated Boundary Current Observations In the Global Climate System
[Uwe Send, SIO]

- Completed one year of continuous Spray glider sampling providing five crossings of the Solomon Sea between the Solomon Islands and New Guinea as a basis for beginning to determine (1) the seasonal cycle of the flow of South Equatorial Current waters through the Solomon Sea, including its western boundary current, to the equator; and (2) the inter-annual variability of that flow
- Demonstrated a dramatic decrease in the extent of the South Equatorial Current and a much weakened flow to the equator in the New Guinea Coastal Current and Undercurrent along the western boundary in March-July 2008, presumably as a consequence of a La Niña event, as showed by Solomon Sea glider sampling
- Implemented and demonstrated field deployed PIES and inductive microcat moorings telemetering data to shore via a glider with acoustic modems
- Completed Ph.D. dissertation by E. M. Douglass on interannual variability of North Pacific Ocean circulation and heat and freshwater budgets
- Analyzed the time mean of drifter, ADCP and CALCOFI – Hydrographic based velocity along CALCOFI Line#90 revealed 100 m deep 'pockets' of ageostrophic velocity that are aligned with regions of geostrophic relative vorticity
- Generated statistical climatology of CalCOFI dataset. Small-scale assimilation in San Diego region



Global Drifter Program (GDP)
[Peter Niiler, SIO]

- Provided to GTS an operational, near-real time data stream of SST, sea level pressure and surface velocity: 1250 drifters distributed globally is the presently operational array size
- Observed the mixed layer velocity on a global basis with 0.5° resolution and, jointly with satellite altimeter data, produced new charts on the seasonal and interannual changing circulation of the world ocean at 0.5° resolution
- Developed and introduced into the drifter construction technological advances in sensors, electronics, power, methods of assembly and deployment packaging, with special emphasis on sensors and aerial deployment methods for hurricane observations
- Provided enhanced research quality data sets of ocean circulation that include drifter data from individual research programs, historical data from instruments different from the SVP Lagrangian Drifter and the corrected data sets for wind-produced slip of drifter velocity. The validation of OGCMs is the current major use of the global drifter velocity data sets

The Argo Project: Global Ocean Observations for Understanding and Prediction of Climate Variability
[Dean Roemmich, SIO]
[Russ Davis, SIO]

- Achieved objective of 3000 active floats with nearly uniform global coverage in November 2007
- Deployed more than 500 Argo floats in the remotest regions of the Pacific and Indian Oceans using the *R/V Kaharoa* through collaboration of Scripps, University of Washington, and NIWA (New Zealand). Without *R/V Kaharoa*, global Argo coverage could not have been attained
- Produced a global gridded Argo dataset for the period 2004-2008, allowing the mean and annual cycle of large-scale ocean temperature, salinity, and circulation to be depicted with unprecedented accuracy, and compared with data from previous eras
- Argo was declared one of the major successes of the Global Earth Observation System of Systems (GEOSS) at its Ministerial Summit in November 2007
- Redesigned the SOLO-II Argo float to provide greater buoyancy control, increased energy efficiency, easier assembly, and reduced size and weight

SIO's Participation in US GODAE: Sustained Global Ocean State Estimation for Scientific and Practical Application
[Dean Roemmich, SIO]
[Bruce Cornuelle, SIO]
[Russ Davis, SIO]

- Provided a balanced heat budget (heat transport, storage, air-sea flux) for the North Pacific Ocean on interannual time-scales based on analysis of subsurface datasets and the ECCO model (E. Douglass)
- Prepared a global monthly gridded Argo climatology, including temperature and salinity profiles from 0 to 2000 m, for the period 2004-2008 by D. Roemmich and J. Gilson

SIO High Resolution XBT/XCTD Transects
[Dean Roemmich, SIO]
[Bruce Cornuelle, SIO]
[Janet Sprintall, SIO]

- Sampled the ocean-spanning North Pacific HRX line (PX37/10/44) four times per year throughout the 16-year era of TOPEX/JASON satellite altimetry, providing a complementary dataset for many studies of seasonal to decadal variability
 - Developed analysis of HRX data together with ocean data assimilation modeling in a Ph.D. thesis provided time-varying heat and freshwater budgets—including oceanic advection, air-sea flux, and storage terms—for the North Pacific Ocean, 1992-2004
-



**Meridional Overturning Variability Experiment
(MOVE)**
[Uwe Send, SIO]

- Achieved successful recovery of moorings now yielding uninterrupted 8-year timeseries of North Atlantic Deep Water transports
- Succeeded at first deployment of entirely NOAA funded equipment on the transport array along 16N

**Scripps Experimental Climate Prediction Center
(ECPC)**
[John Roads, SIO]

- Continued to maintain a significant seasonal forecast presence on the WWW at <http://ecpc.ucsd.edu/>
 - Developed new cloud parameterizations and evaluated their performance on seasonal prediction
 - Developed new lateral boundary forcing schemes for regional dynamical downscaling
 - Developed and evaluated new ECPC Global Coupled Prediction Model (GCPM)
 - Applied ECPM predictions to fisheries outlook and habitats
 - Developed and evaluated new Scripps Coupled Ocean Atmosphere Regional (SCOAR) model
 - Contributed and evaluated extensive ECPC model output for CEOP
 - Continued to provide global support for the ECPC G-RSM through our annual RSM workshop and support of the model master
 - Developed global, hemispheric, US, CA dynamical downscaling climate products
 - Applied global dynamical downscaling for stable water isotope assimilation
 - Performed research on dynamical downscaling of ensemble seasonal forecast
 - Initiated project to dynamically downscale NCEP CFS
 - Started to work on coupled downscaling using SCOAR
 - Contributed a number of RSM simulations to the GEWEX Inter-continental Transferability experiment
 - Began to contribute a number of RSM simulations to the North American Regional Climate Change Assessment Program
 - Expanded Fisheries Outlook web site
 - Developed grid and ran the ROMS model in climatological mode to generate initial conditions
 - Completed data assimilation tests with ROMS
 - Published online Fisheries Outlook for the fishing season of 2009 (spring)
-



Seasonal Climate Forecasts for Firedanger Applications
[John Roads, SIO]

- Made daily 1-day CFS/RSM forecasts 1/1/82-present
- Output daily values of Tmax, Tmin, LST RH, WSP, cloudiness, precipitation frequency as input, along with observed daily precipitation to firedanger code
- Made 10-member 7 month forecast ensemble now on a monthly basis 11/2004-10/2005 and 3-member 7 month forecast for every month from 01/1982-10/2004
- Output forecast daily values of Tmax, Tmin, LST RH, WSP, Cloudiness, precipitation frequency, and precipitation to feed firedanger code
- Constructed monthly, seasonal validation and forecast averages
- Evaluated firedanger forecast skill
- Submitted paper on our initial evaluation (Roads et al. 2008)
- Participated in monthly discussions with NICC on the upcoming fire danger forecast (3/2007-present)
- Participated in annual (Mar/Apr) discussions with NICC and Geographical Area Coordinators on the upcoming fire season
- Submitted annual report (Mar.) to Extended Long Lead Forecast Bulletin on upcoming US and global Firedanger

Economic Benefits of Weather and Climate Forecasts to California Energy Production Management
[Tim P. Barnett, SIO]

- Developed statistical models relating western US peak daily electrical loads to daily maximum temperature
- Estimated joint distributions of daily maximum temperatures for four western regions conditional on PDO and ENSO
- Adapted the WECC electrical system model to simulate hourly to seasonal loads and generation for the western US
- Developed non-linear seasonal statistical forecasts of skew-normal summer temperature distributions
- Analyzed coherence in regional streamflow and hydropower resources across Columbia, Sacramento-San Joaquin, and Colorado River basins
- Partnered with California DWR to analyze streamflow forecasts skill and utility for DWR management objectives
- Analyzed climatic precursors to California heat waves

Regional Aerosol-Chemistry-Climate Observatories for the Indo-Asia-Pacific Region (Project Atmospheric Brown Cloud) and the Maldives Autonomous UAV Campaign (MAC)
[V. Ramanathan, SIO]

- Transferred the daily operations of the Maldives Hanimaadhoo supersite and the Nepal ABC observatory to UNEP-Bangkok while the US ABC program focuses on in-depth study in the effects of ABC on climate, regional water cycle
 - Initiated the California AUAV Air Pollution Profiling Study (CAPPS) to routinely measure the vertical distribution of aerosol particles and ozone using small, light-weight unmanned aerial vehicles equipped with miniaturized instrumentation in California building upon the experience gained during the Maldives Aerosol Campaign (MAC) in 2006 and utilizing much of the same equipment
 - Began collaboration with NOAA's Unmanned Aerial Systems (UAS) Program to explore the capabilities of small unmanned aircraft to support and enhance NOAA's scientific projects, starting with the Pacific Testbed for Atmospheric Rivers (ARs) in California
 - Identified ABC mega city hotspots in Asia during the capstone study, along with five regional hotspots around the world
 - Began planning for a tentative field experiment in 2010, which will combine observations from ships, satellittess, dropsondes, manned and unmanned aircraft
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Global Model Investigation of Warm Season Precipitation for North American Monsoon Experiment [Guang Zhang, SIO]	<ul style="list-style-type: none"> o Participated in the inter-model comparison activities by providing model simulation output to the project
California Applications Program (CAP) [Daniel R. Cayan, SIO]	<ul style="list-style-type: none"> o Collaborated with scientists at NOAA ESRL to show Atmospheric River flood events have occurred throughout the whole west coast region and that all 7 of the major floods during the past 9 years in the coastal Russian River region were associated with atmospheric rivers o Investigated California heat waves to show episodes are most strongly expressed at night have shown a marked tendency to increase during the last few decades o Improved the skill of forecasts for wildfire in forested ecosystems by incorporating temperature forecasts o Showed in Taylor's Ph.D. dissertation that the strongest and most persistent winds in the NE Pacific are concentrated along the California coast between Cape Mendocino and Point Conception, extending west from the coast about 800km o Continued the INFORM project work with key state and federal agencies in California to provide the forecast and management numerical tools to improve water management in the region o Worked with Redmond and CEC to develop a California Climate Tracker that will provide the general public, agency managers, policy makers, and news media updated information on state climate conditions o Continued to work with California state agencies to produce an assessment of a few selected scenarios of climate change, as it impacts several sectors of California's society, economy, and ecosystem
Preparation and Analysis of an Extensive Historic Dataset of Ocean Carbon Dioxide Partial Pressure and Related Measurements [Ralph Keeling, SIO]	<ul style="list-style-type: none"> o Placed preliminary database for DOWNWIND, MONSOON, and LUSIAD expeditions on Scripps CO₂ Program web site, along with accompanying draft technical report (both created by the late Lee Waterman et al. in 1996) o Located data sets and workups for NOVA and EASTROPAC expeditions in Scripps CO₂ Program archives o Identified more detailed task list
CO₂/CLIVAR Repeat Hydrography Program CO₂ Synthesis Science Team [Andrew G. Dickson, SIO]	<ul style="list-style-type: none"> o Published <i>Guide to Best Practices for Ocean CO₂ Measurements</i> (with Chris Sabine & Jim Christian) o Submitted final data for A20, P02, and P16S cruises
Oceanic Measurements of Total Alkalinity [Andrew G. Dickson, SIO]	<ul style="list-style-type: none"> o Presented talk at BERM-11 detailing the overall uncertainty for open-cell alkalinity titrations o Developed approach to use acid-base indicator dye in alkalinity titrations for accurate equivalence point estimation o Analyzed over 300 samples for alkalinity (many of them also for total dissolved carbon)
Southern California Coastal Ocean Observing System (SCCOOS) [John Orcutt, SIO] [Russ Davis, SIO] [Eric Terrill, SIO]	<ul style="list-style-type: none"> o Continued to integrate a broad suite of observations including: surface currents, satellite imagery, wave conditions and forecasts, meteorological conditions and forecasts, water quality, ocean temperature, salinity, chlorophyll, and density in the form of data products and raw data o Provided data support during the October 2007 Southern California wildfires, including real-time meteorological conditions, high-resolution wind forecasts (COAMPS), MODIS rapid response imagery, and satellite imagery



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- Provided environmental data support in May 2008 to the Orange County Sanitation District (OCSD) during ocean outfall repairs (<http://www.sccoos.org/projects/ocsd-diversion/>)
 - Collaborated with the Coastal Data Information Program (CDIP) on the development of a near real-time, customized website for the entrance to the Los Angeles and Long Beach Harbor and San Pedro Channel, created for use by maritime operators and harbor and port managers
 - Supported an industry-led oil spill response exercise conducted in June 2008 off the coast of San Diego where more than 200 participants were involved in National Preparedness for Response Exercise Program (NPREP)
 - Completed and maintained the registration of its regional observation activities in the IOOS Regional Observations Registry, a national database that defines the operational status and distribution of in situ ocean observation activity among the non-federal participants in IOOS
 - Deployed short and long-range surface current mapping radars to observe complex circulations that result from land-ocean-atmosphere interactions
 - Maintained glider lines, an underway CTD line on a vessel of opportunity, and 4 pier-based ocean monitoring stations.
 - Began modeling efforts of a nested ocean model that can operate at 1km resolution and produces time dependent, three-dimensional maps of the velocity, ocean air temperatures, and salinity
 - Continued to receive hydrographic data from agencies operating publicly operated treatment works that maintain monitoring stations for their NPDES. Nearshore climatologies based upon these data are in development
 - Continued to collect and integrate AB411 shoreline water quality data sent from collaborating counties to access, integrate, and display the data alongside other observing system data streams to facilitate the development of decision-making tools
 - Aggregated, integrated, and managed data generated at approximately 400 coastal meteorological stations from multiple networks deployed in Southern California. Data are made publicly available via a Google Maps interface. A public outreach effort to users of the product shows overwhelming support for continued operation
 - Continued to partner with the Ocean Institute in the development and implementation of a comprehensive educational program for teachers and students, being piloted in Orange County, California. The program is now being used in 17 school districts throughout Orange County and reaching approximately 15,000 5th grade students
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HF Radar National Network Data Management Development [Eric Terrill, SIO]

- Configured four data portals, systems designed for collecting HF radar site data and transferring to within the network, and updated for the participating Universities: Oregon State University, Texas A&M University, University of Maine, and University of Miami
- Maintained three nodes, systems designed to act as data repositories and vector processing, and upgraded for the participating Institutions: SIO, NDBC, and Rutgers University
- Integrated level one quality control (QC) algorithms into near real-time processing
- Initiated and began testing phase of WERDA systems (WERA) radial data ingestion
- Standardized the near real-time total vector file format into Network Common Data Form (NetCDF) for distribution
- Hosted the ROWG workshop in September 2007 and drafted an HF radar best practices guide: "Deployment and Maintenance of a High-Frequency (HF) Radar for Ocean Surface Current Mapping: Best Practices"
- Continued development of QA/QC metrics based upon MUSIC direction of arrival statistics
- Participated in the San Diego National Preparedness for Response Exercise Program (NPREP) disseminating HF Radar data in both shapefile and NetCDF formats
- Grown from a single portal and node / 4 sites system at SIO in December 2003 to an operational status with over 900,000 radial files produced by 85 sites from 14 participating institutions in 2006, and is currently operating with over 1.5M radial files produced by 112 sites from 27 participating institutions
<http://cordc.ucsd.edu/projects/mapping/maps/>

B. Biological Systems Research

California Cooperative Oceanic Fisheries Investigations (CalCOFI) Time-Series and the Development of PaCOOS [Elizabeth Venrick, SIO] [Ralf Goericke, SIO]

- Completed four seasonal CalCOFI cruises successfully, including two on the Scripps vessel *R/V New Horizon*
- Described a new pattern of climate variability, the North Pacific Gyre Oscillation (NPGO) based on North Pacific basin-scale variability in wind-driven upwelling and advection. The NPGO is better correlated than previous climate indices with variability in salinity and nutrients, which drive productivity in the Southern California region
- Conducted new analyses that found substantial declines in dissolved oxygen at mid-depths throughout the CalCOFI region since 1984, resulting in a shoaling of the hypoxic boundary on the continental shelf of up to 90 m. There is the potential for cascading effects on the local benthic and pelagic ecosystem, including habitat compression and community reorganization
- Found offshore curl-driven upwelling, rather than coastal upwelling, which is shown to be significantly related to Pacific sardine production in the California Current, potentially a breakthrough in our understanding of sardine production processes
- Estimated spawning habitat for the Pacific sardine and northern anchovy in the California Current using satellite data for SST and surface chlorophyll *a* and the Continuous Underway Fish Egg Sampler (CUFES) data for 1998 – 2005. This could provide a means to track changes in spawning distribution due to climate-induced change to spawning habitats



- Conducted initial experiments on the development of fish otoliths under high-CO₂ conditions indicated that fish may be able to compensate for low pH in developing these critical bony structures
- Completed an analysis of historical CalCOFI samples revealed spatial variation in copepod mortality rates, with lower rates offshore than inshore. Food availability and growth rates are higher inshore, but there are also higher abundances of planktivorous fish there
- Found that iron limitation is a factor limiting phytoplankton production offshore in the California Current and, together with light, in the chlorophyll maximum layer. High iron concentrations are primarily associated with high upwelling zones over the continental shelf. The primary iron supply to the region appears to be from the continental shelf and bottom boundary layer, rather than a deep remineralized source, leading to a sharp onshore-offshore iron gradient.
- Received funding in March from the California Coastal Conservancy to integrate the Scripps and NOAA/NMFS CalCOFI data holdings and to provide web-based queryable access. Queryable access is now available for the first time to CalCOFI's 31,500 hydrographic records
- Combined coastal ichthyoplankton data sets from state, federal and private sources with CalCOFI ichthyoplankton data for analysis of coastal communities in relation to the design of the California MPA system
- Continued sorting of historical CalCOFI samples to develop a time series, based on the abundance of early- and late-stage phyllosoma larvae, of California spiny lobster spawning stock size and potentially an index of future recruitment
- Submitted a collaborative proposal, strongly leveraged off CalCOFI, to the NSF/NOAA CAMEO initiative to conduct field, modeling and retrospective studies of the California Current. If funded, the project would coordinate ecosystem-based fishery research along the west coast, in collaboration with Scripps, Oregon State University, the Northwest and Southwest Fishery Science Centers, and other academic institutions
- Accessioned 2838 CalCOFI samples into the SIO Pelagic Invertebrates Collection. Samples are now web-searchable: <http://www.sioadm.ucsd.edu/plankton/search.htm>. Samples were loaned to seven research groups this year

An Investigation of Nonlinear Forecasting for Improved Stock Projections: Understanding Variability in Fish Populations
[George Sugihara, SIO]

- Found fishing increases boom and bust variability of exploited populations, the implication of which is that the destabilization of the population is a consequence of common fisheries practices that target the larger older individuals. Thus it is significant to restore age-structure in rebuilding depleted stocks
- Confirmed that fishing results in a truncated age and size structure for the population, and further related this to destabilization of exploited populations
- Found nonlinear forecast methods are effective for fisheries. These methods work best when the time series composite is constrained by habitat type or region
- Found physical data for CCE are best described as linear stochastic (auto-correlated noise). They are high dimensional and effectively stochastic
- Found low dimensional nonlinearity in the population dynamics of both exploited and unexploited populations. Dimensionality is a fundamental constraint on the complexity of a model required to achieve a given level of predictability



Coherence of Euphausiid Variability in Southern and Central California Waters [Mark D. Ohman, SIO] [Baldo Marinovic, UC Santa Cruz]	<ul style="list-style-type: none"> ○ Constructed 3 euphausiid databases in MySQL ○ Constructed a plot gallery of unpublished euphausiid distributional maps from Dr. Ed Brinton's research ○ Enumerated euphausiid samples from Central California ○ Completed digitization and QC of 192,000 euphausiid records from 1949-2007 ○ Designed MySQL GUI web interface ○ Tested and verified queries
The Center for Stock Assessment Research (CSTAR) [Marc Mangel, UC Santa Cruz]	<ul style="list-style-type: none"> ○ Completed Ph.D. Thesis of Anand Patil, Bayesian Nonparametrics for Inference of Ecological Dynamics ○ Completed Ph.D. Thesis of Matt Taddy, Bayesian Nonparametric Analysis of Conditional Distributions and Inference for Poisson Point Processes ○ Developed SELMA (Steelhead Early Life-History Mass Accumulation)—an open-source, free program developed in R to facilitate the fitting of a growth model to data collected from tank-reared fish growing under known temperature and food availability regimes ○ Accommodated the following CSTAR Seminar Series visitors: <ul style="list-style-type: none"> • Anastassios Tsoularis (Massey University), Some Mathematical Models of Batesian Mimicry • Kai Lorenzen (Division of Biology, Imperial College London, UK and Center for Fisheries Enhancement, Mote Marine Laboratory, Sarasota, Florida, USA): Population dynamics of fisheries stock enhancement: ecological insights and new tools for management • Cam Ainsworth (NMFS, Seattle): Atlantis Modeling of the Upper Gulf of California: EBM support for small-scale fisheries • Barney Luttbeg (UC Davis): Predator and prey movement rules shaped by game dynamics • Perry de Valpine (UCB): Understanding noisy population dynamics: frequentist and Bayesian inference with state space models • Steve Railsback (Railsback, Long and Associates): Modeling behavior in individual-based population models...or: Why theoretical ecologists should be forced to work on applied problems
A Joint Program for Training and Research in Marine Resource Management Modeling [James Wilen, UC Davis]	<ul style="list-style-type: none"> ○ Continued collaborative research between program's first graduating student (Mike O'Farrell) and current student Liz Moffitt ○ Graduated fourth ARE Ph.D. student, Jose Cancino ○ Submitted completed thesis work of Hiro Uchida and Josh Abbott in several outlets ○ Published ongoing research work with other students in progress ○ Oversaw two program students successfully compete for and were granted Research Fellowships to support fisheries thesis work ○ Brought two new students into program to begin new research topics
Studies in Groundfish Habitat [Peter Adams, UC Santa Cruz]	<ul style="list-style-type: none"> ○ Improved understanding of essential fish habitats for groundfishes on continental shelf and upper slope ○ Continued to improve visual survey methods that will improve stock assessments of fish species in high-relief habitats ○ Quantified distribution, abundance, type, and ecological impacts of marine debris (in particular, lost fishing gears) on seafloor habitats off central and southern California



	<ul style="list-style-type: none"> ○ Initiated monitoring plan for deepwater component of newly established MPAs off central California ○ Developing coast-wide seafloor habitat maps within state boundaries
Cooperative Studies of Pacific Coast Salmon: NOAA Fisheries and the University of California, Santa Cruz [Peter Adams, UC Santa Cruz]	<ul style="list-style-type: none"> ○ Led NOAA Fisheries Technical Recovery Teams developing scientific criteria to serve as a basis for ESA-listed salmonid species recovery plans, and served on the Klamath River Technical Advisory Team and Salmon Technical Team to provide stock assessment and harvest management support ○ Developed and applied a novel approach using DIDSON sonar to estimate abundance of green sturgeon in the Rogue River, Oregon ○ Completed a NMFS Fisheries and the Environment (FATE) research project "Does inclusion of environmental variables in the Klamath River fall Chinook abundance forecast model improve its performance?" ○ Completed a genetic stock identification project for the 2007 ocean salmon fisheries ○ Developed hierarchical statistical models for estimating steelhead run-size from RFID tag data ○ Developed an index for extinction-effective population size to be used in endangered species management ○ Compared population dynamics of fall-run Chinook salmon spawning in the California Central Valley, the Klamath Basin, and the Columbia River Basin using multivariate method and demonstrated their potential similarity in underlying processes ○ Modeled the effect of autocorrelated stochastic environment on the age of maturity of Chinook salmon and demonstrated a potential reason for change in their maturation rate
Freshwater Ecology Research Collaboration [Peter Adams, UC Santa Cruz] [J. Moore, UC Santa Cruz]	<ul style="list-style-type: none"> ○ Equipped the lab with needed field and laboratory equipment ○ Attained grants in collaboration with several researchers to fund future research ○ Continued to publish in scientific journals ○ Recruited two graduate students for the lab
Shipboard Monitoring of the California Current System Off Central California [Baldo Marinovic, UC Santa Cruz] [Francisco Chavez, MBARI] [Curtis Collins, Naval Postgrad School]	<ul style="list-style-type: none"> ○ Made physical and biological measurements along CalCOFI lines 67 and 60 in November 2007 using the NOAA ship <i>David Starr Jordan</i> ○ Placed personnel on the NOAA ship <i>David Starr Jordan</i> to collect physical, chemical, and phytoplankton measurements along the northern portion of the CalCOFI grid up to San Francisco in the Winter and Spring of 2008. ○ Made physical and biological measurements along CalCOFI lines 67 June 2008 using the <i>R/V Pt Sur</i>. Bad weather prevented sampling along Line 60 ○ Took measurements during the Fall of 2007 and the Summer of 2008 included ○ Took continuous underway sampling of SST, SSS, Fluorescence, PCO₂, and meteorological parameters ○ Conducted CTD/Rosette casts including assays for nutrients (nitrate, silicate, phosphate), chlorophyll A, primary production, phytoplankton taxonomy and cell counts ○ Completed Bongo tows (oblique) to 210 m to sample macrozooplankton/ichthyoplankton—processed for zooplankton biovolume and krill abundance and species composition and subsequently archived for future analyses with NMFS La Jolla Lab



Phytoplankton Studies in Cooperation with the U.S. Antarctic Marine Living Resources (AMLR) Program

[Osmund Holm-Hansen, SIO]

[Christopher Hewes, SIO]

- Found that Chl-a concentrations in surface waters of the AMLR sampling grid were generally equal to or slightly less than the 18-year historical mean values. In contrast to many years, chlorophyll-a concentrations during Leg II were lower than during Leg I
- Found that all areas in both Legs had colder and saltier surface waters than normal, suggesting that the outflow from the Weddell Sea was stronger in 2008 than the norm from past years
- Completed analysis of the phytoplankton data in relation to the salinity gradient in surface waters which also suggested that Weddell Sea shelf waters intruded further into the AMLR survey area in 2008 as compared to previous years
- Completed analysis of the fluorescence yield and chlorophyll-a data indicates that phytoplankton in Drake Passage waters were experiencing greater photo-physiological stress due to Fe limitation than in recent years
- Generated continuous profiles of chlorophyll-a and PAR which will be used to (i) to analyze chlorophyll-a concentrations in relation to physical, chemical, and optical conditions in the water column, (ii) to provide a measure of physiological stress (e.g. fluorescence yield), and (iii) when combined with the profile of solar irradiance, one can estimate the rates of primary production in the water column
- Completed inter-calibration of our cosine profiling PAR sensors and the LI-COR cosine PAR sensor (LI-COR model LI-190) used to measure incident light continuously over a 24-hour period. This way we were able to measure euphotic zone depth (1% isolume for in situ to incident surface PAR) for all daytime CTD casts
- Incubated short-term photosynthesis-irradiance (P vs. E) response for natural populations from 15 stations during Leg I with ^{14}C sodium bicarbonate to estimate primary production. Functional absorption cross-section, and turnover time of photosystem-II on these samples were assessed using fast repetition rate fluorometry
- Measured particle and soluble absorption (Leg I): Absorption spectra from 300 to 800 nm of total particulate matter (concentrated on a Whatman GF/F filter) and dissolved substances from 15 stations using a double beam Cary 1E spectrophotometer
- Returned particulate Organic Carbon and Nitrogen (Leg I): Water samples from 15 stations to SIO for analysis of POC and PON by gas chromatographic techniques
- Measured size distribution of particles (only in Leg I): Size distribution of particles from 2 to 64 μm in water samples from 15 stations using a Multisizer II Beckman Coulter Counter
- Deployed underwater light regime (only in Leg I): An Integrated Optics Package (IOP) and a Profiling Reflectance Radiometer system (PRR) at a total of 15 mid-day CTD stations. Data sets of 14 IOP casts and 41 PRR800 casts were acquired. The reference sensor (PRR-810) of the reflectance radiometer system continuously recorded surface downwelling irradiance at 19 spectral channels including surface incident PAR throughout the survey

Historical Ecology of Florida Keys Coral Reef Ecosystems

[Jeremy Jackson, SIO]

- Completed data collection and began data extraction and analysis
 - Published a book chapter on project research and submitted 2 journal articles for publication
-



	<ul style="list-style-type: none"> ○ Created a database of historical (1760-1985) references to the abundance and distribution of coral reef associated fishes, invertebrates mammals, birds and reptiles and have begun to analyze these data ○ Presented results of the research at the Gulf and Caribbean Fisheries annual meeting in Punta Cana, Dominican Republic, American Association for the Advancement of Science in Boston, MA and the International Coral Reef Symposium in Fort Lauderdale, FL
Monitoring Cetacean Response to Ship Noise Near the Channel Islands National Marine Sanctuary [John Hildebrand, SIO]	<ul style="list-style-type: none"> ○ Measured significantly higher noise levels in Santa Barbara Channel, compared to other regions ○ Found that when a ship is within 4km of the recording instrument, the noise levels are elevated by 15-20 dB and blue whale calls are no longer detectable, suggesting a decrease in communication range of the animals to less than 4km ○ Received permit to put in 2 additional recording sites in the Sanctuary boundaries (instruments are currently recording) ○ Found that based on an analysis of ship records from the AIS, ship speed did not significantly change when notices to Mariners were sent out suggesting a decrease in speed to avoid blue whales using the area
Measurement and Modeling Analysis of Organic Aerosol and Their Cloud Interactions [Lynn M. Russell, SIO]	<ul style="list-style-type: none"> ○ Found that organic functional groups and elemental components measured in DYCOMS-II marine stratocumulus clouds partition between the cloud droplets and unactivated particles at approximately 30% mass scavenged for the 6 research flights studied ○ Found that single particle microscopy indicated that most of those particles contained a large fraction of sea salt by mass, such that the particles were inferred to be internal mixtures of sea salt, sulfate, organics, and elemental components ○ Continued analysis of TEXAQS measurements show how the organic functional group composition changes with distance from the pollution source and how the correlation of organic mass measured by other methods changes over the course of the campaign
Interannual Variability of Small Pelagic Spawning Habitat in the California Current [David Checkley, SIO]	<ul style="list-style-type: none"> ○ Published paper on use of satellite data to predict spawning habitat of sardine and anchovy (Christian Reiss, lead author) ○ Made progress on use of Kernel Density Estimation of spawning habitat of sardine and anchovy ○ Published paper on pelagic ecosystem structure and its use by anchovy and sardine, including the importance of regions of wind-stress curl



C. Research in Extreme Environments

Methane Seeps Under Hypoxia: Novel Ecosystems within Eastern Pacific Oxygen Minimum Zones

[Lisa Levin, SIO]

[Peter Lonsdale, SIO]

- Discovered by trawling a new methane seep site at 350 m located off El Quisco, Chile (~33° S)
- Documented that methane seeps enhance continental margin biodiversity, but this effect is suppressed by low-oxygen OMZ waters
- Discovered methane-fueled invertebrate assemblages on the New Zealand margin: ampharetid polychaete beds and sponge mats

D. R&D on Observations Systems

Joint Project Agreement Concerning the National Spatial Reference System in California

[Yehuda Bock, SIO]

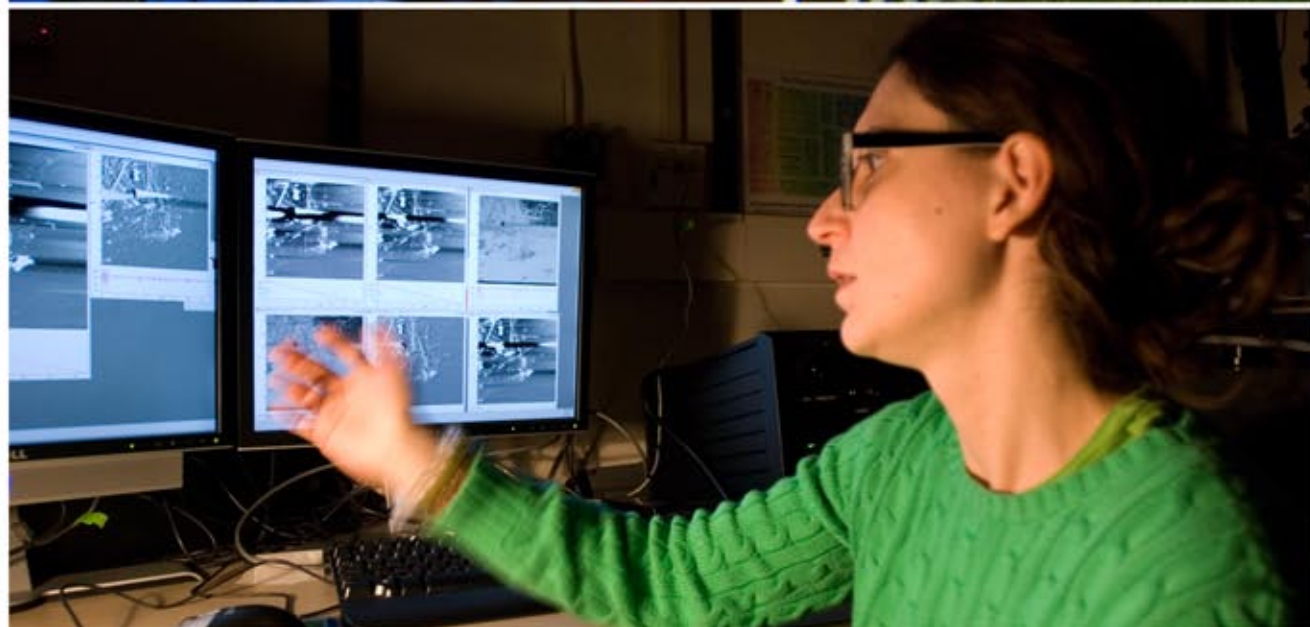
- Incorporated and analyzed Caltrans data for the Northern San Joaquin Valley 2006 Height Modernization project
- Analyzed GPS data from the North San Joaquin Valley 2006 and Central Coast Height Modernization 2007 projects – created first version of bluebook files (B-file, G-file, SERFIL) from CSRC database
- Created bluebook files for North San Joaquin Valley 2006 Height Modernization project
- Published results and enhanced analysis of the Southern California 2006 Height Modernization project
- Performed orthometric adjustment for the Central Coast Height Modernization 2007 project and prepared final report to be submitted to NGS
- Enhanced PGM software (server and client side) for height modernization and geodetic control projects – released version 1.2 of PGM client
- Developed crustal motion model for California and evaluated and endorsed HTDP 3.0 for NGS
- Published and circulated proposal for statewide California Real Time Network (CRTN) - held series of meetings at Scripps with key players (UNAVCO/PBO, Caltrans, and JPL) and circulated proposal to California surveying organizations
- Held two successful “sold-out” RTN workshops with CLSA in May (South Region: Ontario, North Region: San Jose)
- Submitted list of proposed “California CORS” to NGS, to be used in their OPUS solutions and other applications
- Working with NGS on NSRS readjustment to correct errors found in last year’s readjustment
- Completed transition to new financial reports requested by CSRC Executive Committee
- Engaged in significant outreach efforts
- Participated in National Height Modernization activities

Implementation of a Real-Time Precipitable Water Capability Using the Global Positioning System

[Yehuda Bock, SIO]

[Peng Fang, SIO]

- Succeeded at reliably running 24 hour session (on a faster processor for the primary analysis) with an automatic switching system to a failover system on a slightly slower secondary system
- Employed new global reference frame, absolute antenna phase center model, improved ocean tidal loading model, new differential phase bias correction, better ambiguity resolution for longer baselines
- Maintained satellite health checks on published (on web) NANU announcement as well as the health flags embedded in the broadcast messages





THEME A: CLIMATE AND COASTAL OBSERVATIONS ANALYSIS, AND PREDICTION RESEARCH



Consortium on the Ocean's Role in Climate (CORC II)

Russ Davis (SIO)

NOAA Technical Contact: Mike Johnson (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The objectives of the Consortium on the Ocean's Role in Climate (CORC) are (1) to maintain critical elements of the ocean climate observing system in the Pacific Ocean and disseminate descriptions of observed climate variability, (2) to develop new observational and data-assimilation methods for documenting and diagnosing climate change in the ocean, and (3) contribute to the assessment of climate change and the predictability of climate variability.

During this no-cost-extension period, final activities in CORC-II's basin-scale high-quality Voluntary Observing Ship (VOS) measurements of ocean structure and transport, and surface-temperature and surface current measurements by drifters provided quantitative measures of how the ocean participates in broad-scale climate variability. These two programs are continued and reported as separate JIMO initiatives. The no-cost extension period allowed for a smooth transition of the research from the CORC umbrella, with no change in the original scope or objectives of the program. Other CORC-II activities, including Spray glider transects and data assimilation modeling were concluded in the previous year.

Research Accomplishments

High Resolution eXpendable bathythermograph (HRX) transects (Roemmich) were carried out along basin-spanning routes:

PX37/10/44 (North Pacific - San Francisco to Hawaii to Guam to Hong Kong)

IX15/21 (South Indian - Fremantle to Mauritius to Durban)

During each cruise, XBT temperature profiles (0-800 m) are collected at spatial intervals from 10 km near ocean boundaries and the equator, to 50 km in interior regions - resolving boundary currents and interior eddies for calculation of ocean-wide integrals of geostrophic transport. A web site for the project, with downloadable data, is maintained at <http://www-hrx.ucsc.edu>. HRX data are transmitted on the GTS immediately after collection for real-time applications.

Surface drifter (Niiler) sampling of surface currents and surface temperature were maintained as part of the Surface Velocity Program (SVP). SVP enhancements have included additional drifter deployments in the tropical Pacific Ocean, including the Luzon Strait. Analysis of the latter array indicates strong current systems in the Luzon Strait and off the east coast of Vietnam. This southward flowing current system is down-welling cold water from the surface, both due to the geostrophic tilting of isotherms as well as from the convergence of Ekman transport in the strong current region. Other deployments included Sea-Bird MICROCAT salinity sensors on SVP drifters in the East China Sea, focusing on changes of flow of near-surface fresh water from the closure of the Yangtze River dam in 2004 and the potential influence of the reduced fresh water flow toward the Korean ecosystem.

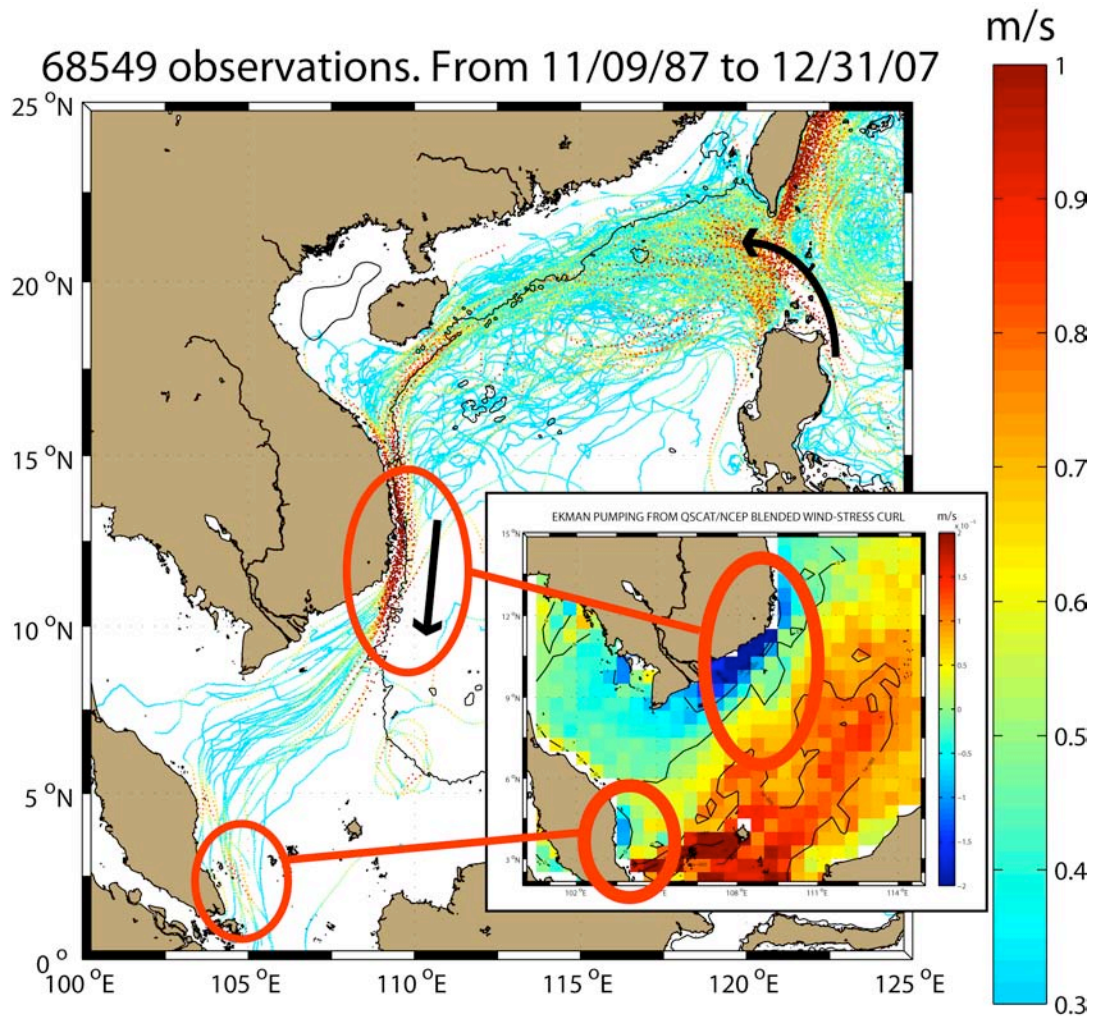


Fig. 1 The summary of 1984-2007 historical drifter observations in the South China Sea during October-January time periods. The drifter observations of location are colored relative to speed along the track, with red color being the largest values. The inset in the lower right depicts the theoretical Ekman divergence computed from QSCAT wind stress data at NCAR



Consortium on the Ocean's Role in Climate (CORC III): Integrated Boundary Current Observations In the Global Climate System

Uwe Send (SIO)

NOAA Technical Contact: Mike Johnson (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The project plans to develop, demonstrate, and implement a system that can fully monitor the intensity (mass and heat transports) of most boundary currents in a sustained and routine mode, delivering indicators about the state of those regimes in near-real-time. To this end we will merge several technologies and techniques that have been used by the PIs in the past, and that were partly developed in prior CORC phases. These include:

- end-point moorings (with CTD sensors throughout the water column and bottom pressure sensors) at the ends of a section to determine the dynamic height difference, and thus geostrophic transports, as a time series.
- underwater gliders to estimate the heat transport through a section, by providing the horizontal (and vertical) distribution of heat content and its correlation with the flow.
- inverted echosounders plus bottom pressure (PIES) distributed along the section to be monitored. These will yield 2 vertical integrals (e.g. dynamic height and heat content) at each location, providing the depth (and time) coverage along the section that the gliders cannot.
- data telemetry for the PIES and (subsurface) moorings using acoustic modems between these and the gliders. In very high (surface intensified) current regions, the gliders may need to remain submerged on one of the round-trip crossings each time. In this case, a navigation capability will be needed in the gliders to pass within close enough proximity of the PIES and moorings.
- data assimilation for determining heat and flow distributions, and thus the full mass and heat transports, that are consistent with all the data types collected, with satellite altimetry, with the forcing fields (wind) and with up/downstream and offshore information.

The pilot and testbed application will be carried out in the California Current which has large climate and socio-economic relevance and does not have a routine monitoring system. Operation along CalCOFI line 90 in southern California assures synergy with other programs, and coincides approximately with the high-resolution XBT line PX31 which will contribute comparison data and connect sampling to the basin interior. In addition automated surface drifter releases will quantify the eddy variability and the Ekman flow in the boundary current region. Later in the project, implementation of the system in the climatically highly relevant western boundary current of the low-latitude western Pacific is planned (which feeds the Equatorial Undercurrent through the Solomon Sea).

Research Accomplishments

Task A: Glider Operations in Boundary Current Observations

The period July 2007 through June 2008 saw the inauguration and first successful year of Spray glider sampling in the Solomon Sea. This sampling is meant to determine the inter-annual variability of flow from the South Equatorial Current to the equator where it is the main source for the Equatorial Undercurrent, the water whose upwelling plays a central role in the ENSO cycle. This sampling yielded one transit from New Guinea to the Solomons and two round-trips from the Solomons to New Guinea then returning to the Solomons. The glider measures sections of the depth-average velocity from the surface to approximately 600 m and of temperature and salinity to 600 m. Data is reported in real time to SIO and more complete data are recorded internally for recovery with the glider.



The scientific results are tantalizing but incomplete. However, this first year of operation has shown that glider monitoring the climatically important New Guinea Coastal Current and Undercurrent is feasible and cost effective. It has also shown that in adverse conditions the gliders are at the limit of their capability and, remarkably, that the leading cause of loss of data is fish attack of the gliders, leaving clear marks of attacks by sharks and billfish on the gliders.

In addition, the transponding glider (glider with acoustic modem to telemeter data from moorings and PIES) was implemented and has been undergoing sea trials since the CORC test mooring was deployed in January 2008. Two missions have been carried out to date, with acoustic data downloads from the test PIES and subsurface mooring off San Diego. All of the 8kb of PIES data collected until Aug'08 were downloaded and telemetered by the glider, and 28kb of the mooring data were recovered during the last mission, at ranges up to 3.5 km. Work is underway to improve the data volume and reliability of the acoustic communication. Two more transponding gliders will be built and ready for deployment on the California Current section before the end of 2008.

Task B: Moorings and PIES in the Integrated Boundary Current Observations

After the technical implementations in the first year of the project, in October 2007 a PIES (inverted echosounder with bottom pressure sensor) was deployed in 900m water depth off San Diego. This was equipped with a Benthos acoustic modem and had been modified to feed daily average data to the external modem. After deployment, successful acoustic communication was established up to distances of 6km from the boat. In January 08 a cruise took place on *R/V Sproul* to deploy a test subsurface mooring in the vicinity of the PIES. This mooring carries a newly developed controller which inductively collects data from 2 microcats on the mooring and passes them to a Benthos acoustic modem. Since then, 2 glider missions have visited the site with the PIES and the mooring, and downloaded data acoustically from the systems.

Work is underway to deploy the first real implementation of moorings and PIES across the California Current. A seven-day cruise on *R/V New Horizon* is firmly planned now in September 08 to deploy 2 tall moorings (4000m) with approximately 15 microcats each, and five PIES along the same section, all carrying the new acoustic modem capability for data downloads via gliders. The PIES have been modified further to pass the raw rather than daily average data to the modems. More modems have been purchased for the PIES, moorings, and gliders. In addition, simulations with historical data are under way to determine the accuracy and required sampling with the moorings and the PIES.

Task C: XBT data in support of the California Current observing system

High Resolution XBT transects across the California Current near San Francisco and Los Angeles are being analyzed to study the structure and variability of the current system. E.M Douglass's Ph.D. dissertation on interannual variability in the North Pacific Ocean included an analysis of the northeast Pacific, showing that increases in the eastward transport of the North Pacific Current mostly turn southward into the California Current and its offshore extensions. This dissertation also included a full heat and freshwater budget for the North Pacific Ocean based on the High Resolution XBT transects and a data assimilation model. Ongoing work on transport in the California Current is aimed at defining the offshore structure of the current and its alongshore variability between San Francisco and Los Angeles.

Task D:

a) Analysis of historical observations in the Southern CCS:

The hydrographic data from 1949-2008, the SVP drifter data from 1985-2008, the satellite altimeter from 1992-2008 and ADCP data from CALCOFI ships were combined to compute comprehensive horizontal maps of velocity along CALCOFI Lines 77-93. These analyses produce time-mean horizontal maps of surface circulation in the southern portion of the CCS and vertical sections along CALCOFI Lines.

The data on Line #90 shows significant ageostrophic velocity component normal to Line #90 line in water depths shallower than 100m. The spatial structure of ageostrophic velocity cannot be entirely due to wind driven Ekman currents because the wind along Line #90 does not have a spatial structure commensurate with the location of the spatial structure of the ageostrophic current patterns. Data on Line #90, as well as the other CALCOFI lines where ADCP data is available, is being inspected to determine whether interaction with the wind and the relative vorticity of the time mean circulation might lead to these anomalies.

b) Design and testing of long term moored timed release drifter:

An initial design exists of the timed-release mechanism and ocean bottom-resting configuration for drifters. Burn wire technology was adopted from geophysics research group at SIO that forms the connection to a low cost resting pod on the ocean bottom. The new drifter configuration float is a 4000m pressure resistant Benthos glass sphere with a thru-hull cable to the burn wire. Initial test in the OAR test pool were halted due to leaks in



the glass sphere, which was solved subsequently. This initial design was part of an undergraduate design course in Mechanical/Electrical Engineering for Christopher Huynh. Design modifications and testing are continuing.

Task E: Modelling and assimilation of future CORC data in the California Current We have been working on technical details necessary to enable the California Current System (CCS) state estimation for hindcasts. We have finished a preliminary statistical climatology of the CalCOFI observations, including relations to forcing time series. This includes seasonal cycles and the relation between the CCS and climate indices (PDO, ENSO, NPI). In addition, we have been successful in making the assimilation system work on a small scale in the San Diego region, testing a small-scale extreme case for the CCS assimilation system.

Work continues on coding statistical and dynamical constraints for the model initial and boundary conditions. The problem is to make a forward model that produces T,S,U,V from fields of displacement, spiciness, and surface diabatic changes. As mentioned before these are helpful for the shorter runs to be used for the CCS assimilation. The constraints are being constructed as part of the investigation of CalCOFI statistics.

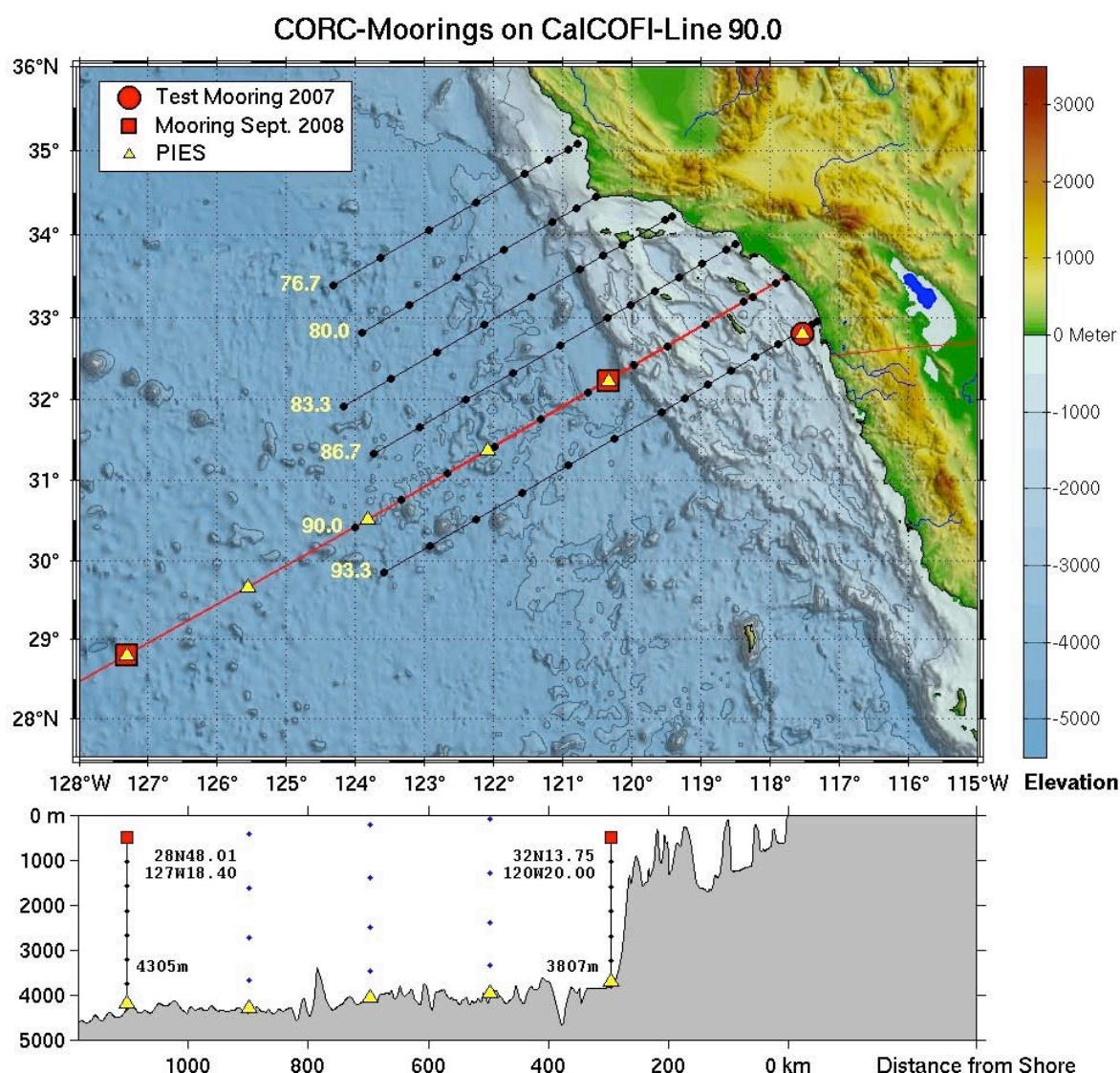


Fig.1 SPRAY glider with CORC modifications: acoustic modem transducer for 10km range communication incorporated into tail section (left). Inverted echosounder (white sphere) with the acoustic modem (black cylinder) modification and assembly (right) Map of the test mooring and test PIES (near San Diego) deployed in Nov'07 and Jan'08, and of the two moorings and 5 PIES to be deployed on line 90 in September 08

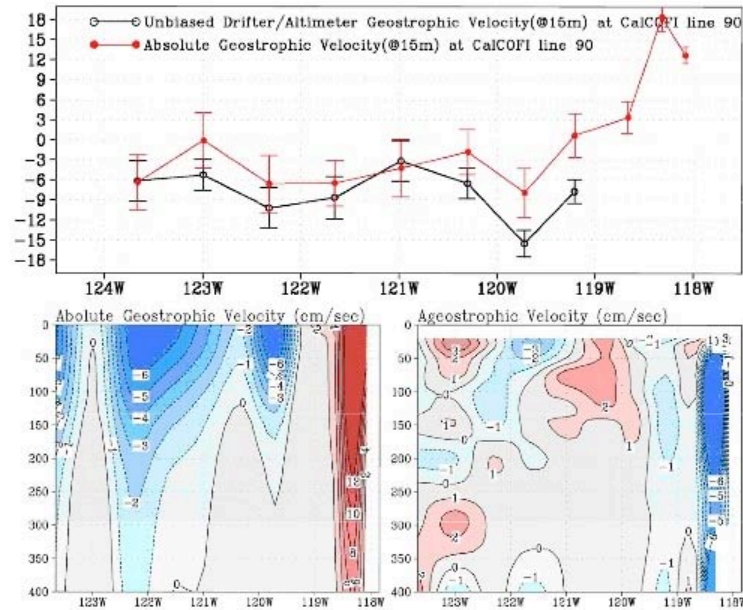


Fig. 2 The 15m depth surface geostrophic velocity components normal to Line #90 from drifters and altimeters (black; upper panel) and 250 m depth ADCP referenced geostrophic velocity (red; upper panel) with the sub-surface continuation of the absolute geostrophic velocity component (left lower panel) and the ageostrophic component (right lower panel)



Global Drifter Program (GDP)

Peter Niiler (SIO)

NOAA Technical Contact: Mike Johnson (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The "Global Drifter Program" (GDP) is the principal international component of the JCOMM "Global Surface Drifting Buoy Array." It is a Scientific Project of the DBCP of WMO/IOC. It is a near-operational ocean-observing network of drifters that, through the ARGOS satellite system, returns data on ocean near-surface currents, SST and atmospheric pressure (and winds, subsurface T(z) and SSS) and provides a data processing system for scientific utilization of these data.

The scientific objectives of the GDP, and its operational and research partners, are to:



- Provide to GTS an operational, near-real-time data stream of SST, sea level pressure and surface velocity: 1250 drifters distributed globally is the presently desired array size.
- Observe the mixed layer velocity on a global basis with 0.5° resolution and, jointly with satellite altimeter data, produce new charts on the seasonal and interannual changing circulation of the world ocean at 0.5° resolution.
- Develop and introduce into the drifter construction technological advances in sensors, electronics, power, methods of assembly and deployment packaging, with special emphasis on sensors and aerial deployment methods for hurricane observations.
- Provide enhanced research quality data sets of ocean circulation that include drifter data from individual research programs, historical data from instruments different from the SVP Lagrangian Drifter and the corrected data sets for wind-produced slip of drifter velocity. The validation of OGCMs is the current major use of the global drifter velocity data sets.

Research Accomplishments

In 2007-2008, 915 drifters with SST sensors were built and delivered by JIMO to AOML for deployment in the global ocean. Presently there is an array of 24 SVP-T(z) (Temperature-Chain) Hurricane drifters and 16 SVP-W (wind) drifters in Keesler AFB waiting deployment into North Atlantic hurricanes in the August-October, 2008 hurricane season. In addition, 16 SVP-T(z) and 8 SVP-W drifters were shipped to Guam to participate in the international TCS-08 Typhoon study. This marks the 4th consecutive year of level funding and acquisition of drifters to maintain a 1250 element global array with full cooperation of JIMO national and international partners. New charts of the global ocean circulation have been prepared by combining drifter and altimeter data (Figure 1).

Deployment of wind and thermistor chain drifters in Hurricane Dean – August -07

The thermistor chain development in 2004-05 was in response the requirements of the National Hurricane Center to improve hurricane strength prediction using subsurface temperature information. To this end, we successfully developed, with Clearwater, Inc. and Pacific Gyre, Inc., the methodology for attaching digital-inductive modems on to subsurface, coated wire drifter tethers that hang from a SVP-W wind drifter float. In 2006, 2007 and 2008 we built 12 SVP-W (Minimet) and 8 SVP-T(z) (ADOS) drifters and shipped these to Keesler AFB, MS for deployment by the 53rd Hurricane Hunter C-130 squadron. On August 19, 2007 20 drifters were parachuted in front of category 4 Hurricane Dean, and all produced data on GTS before and through the passage of the storm.

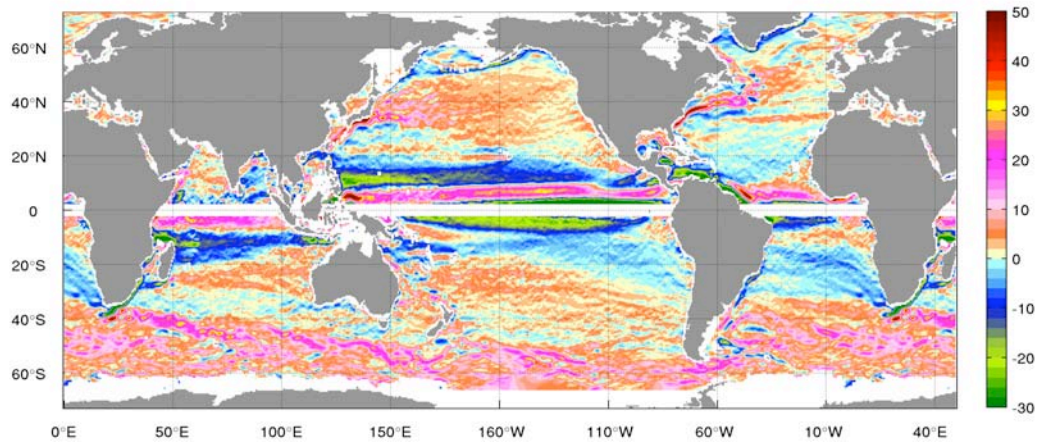


Fig. 1 The high spatial resolution 1992-2007 time mean zonal geostrophic derived from drifter and satellite data). Note the striations of zonal velocity in the eastern North Pacific that extend from the California Current meanders to the longitude of Hawaii

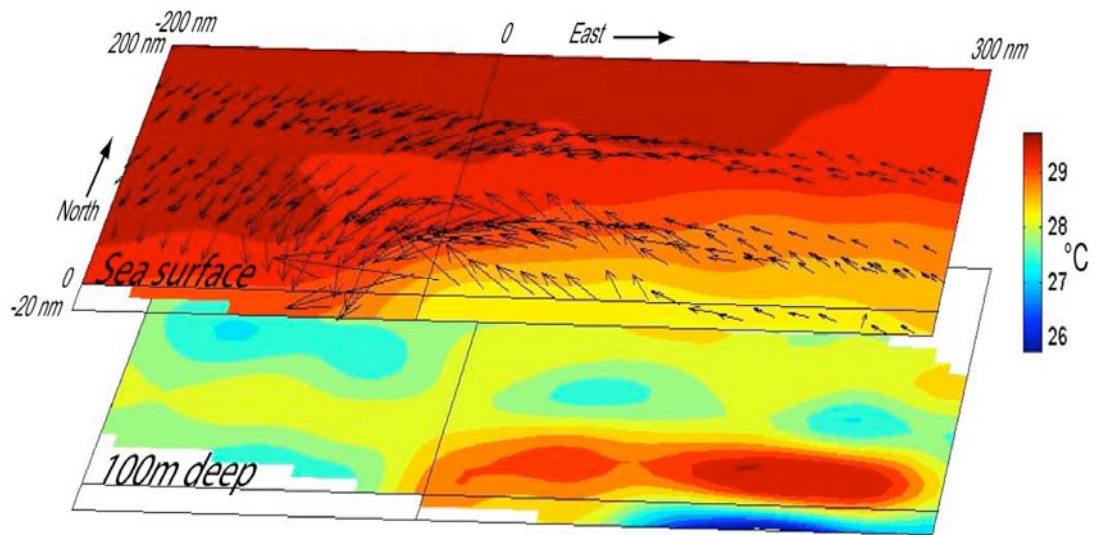


Fig. 2 The drifter observed SST (upper panel) and temperature at 100m (lower panel) relative to the center of Hurricane Dean in August 2007. Note that the SST cools and the 100m temperature warms during the storm passage (courtesy R. Lumpkin, AOML)



The Argo Project: Global Ocean Observations for Understanding and Prediction of Climate Variability

Dean Roemmich and Russ Davis (SIO)

NOAA Technical Contact: Steve Piotrowicz (OAR)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

Research Objectives and Specific Plans to Achieve Them

Argo is an international collaboration providing a global array of profiling CTD floats for a broad range of operational and scientific applications (<http://www.argo.ucsd.edu>). The Argo array, now including about 3100 active floats (Figure 1), is providing unprecedented real-time views of the evolving physical state of the ocean. These measurements reveal the physical processes that balance the large-scale mass, heat, and freshwater budgets of the ocean on basin-to-global scale. Argo is a large initiative for oceanography, merging research and operational objectives to provide a uniquely valuable global dataset for climate science, ocean state estimation, seasonal-to-decadal forecasting, and other applications. All Argo data are freely available in near real time.

SIO plays a number of key roles within U.S. and international Argo. The U.S. provides 50% of the international array, including instrumentation development, float production and deployment, communications and data management, and scientific analyses to demonstrate the value of Argo data. SIO produces and deploys one-fourth of the U.S. floats, carries out float technology development, participates in delayed-mode quality control, coordinates the U.S. Argo partnership, and provides leadership for International Argo.

Research Accomplishments

During the past year (07/2007 – 06/2008), 100 SIO Argo floats were built, shipped and deployed. All but 4 of these instruments are presently active. An additional 50 floats have been built and are awaiting shipment in early July.

The total number of active SIO Argo floats is now 450. For all active floats, profile and engineering data are carefully monitored to identify any technical problems with the instrument or sensor. Technology development continues to focus on further improvements in reliability and capability of profiling floats. A complete redesign of the SIO SOLO float is near completion, with prototype SOLO-II instruments to be deployed in July 2008. The new SOLO design will provide greater buoyancy adjustment and more robust operation. Float technology aspects of SIO Argo are overseen by R. Davis.

Scientific quality control of all SIO Argo profile data has been carried out by J. Gilson and M. Scanderbeg according to protocols set by the international Argo Data Management Team. All eligible delayed-mode profiles (i.e. > 12 months old) have been reviewed. SIO Argo data are available from either of the two Argo Global Data Assembly Centers.

D. Roemmich has been Chairman of the international Argo Steering Team since its inception in 1998. The AST, which is responsible for coordinating the international Argo partnership, met in March 2008 at the UK Met Office in Exeter England. The meeting report for AST-9 is available from http://www.argo.ucsd.edu/FrMeeting_reports.html. J. Gould continues as Argo Director Emeritus and part-time consultant, supporting a variety of AST activities, with assistance from M. Scanderbeg.

Since most SIO Argo floats are in the tropical and South Pacific, scientific analysis efforts are focused there and on global research. A major effort has been construction of a gridded Argo dataset for the period 2004 – 2008. Monthly fields were produced by objective mapping on a $1^\circ \times 1^\circ$ grid from 60°S to 65°N . The gridded Argo



dataset has been used both to describe the mean and annual variability of temperature, salinity, and dynamic height as well as to characterize decadal variability by comparison to previous climatological datasets.

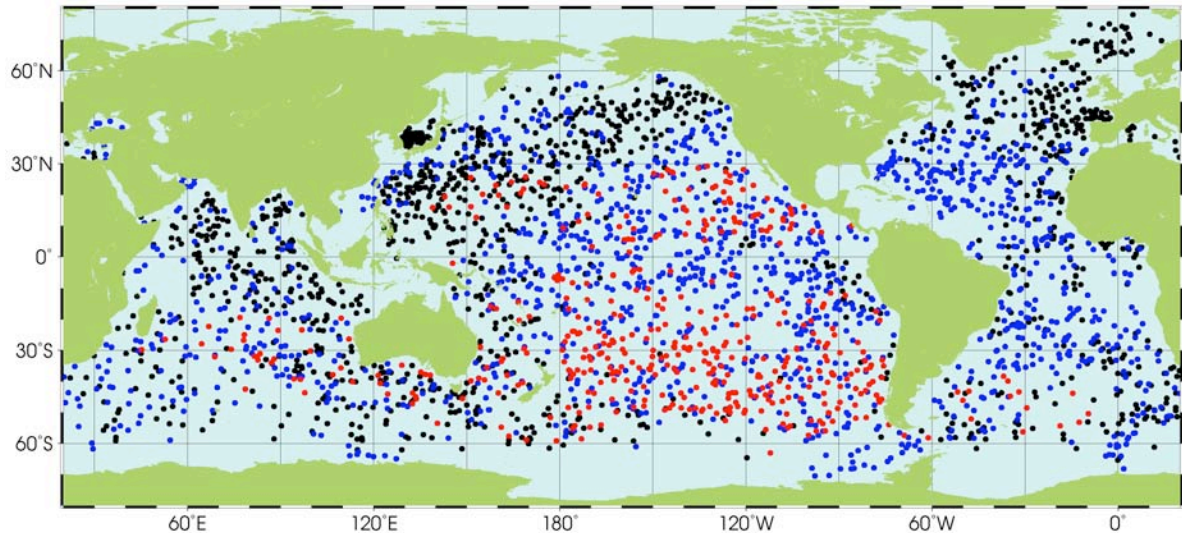


Fig. 1 Present location of active 3100 Argo floats, including SIO (red), other U.S. (blue), and international floats (black)



Fig. 2 SIO Argo PI Dean Roemmich (center) examines Argo floats with New Zealand Minister of Research, Science, and Technology Hon. Steven Maharey (right) and NIWA N.Z. Research Director Rob Murdoch on R/V *Kaharoa* prior to a deployment cruise in October 2007. Photo by Alan Blacklock, NIWA



SIO's Participation in U.S. GODAE: Sustained Global Ocean State Estimation for Scientific and Practical Application

Dean Roemmich, Bruce Cornuelle and Russ Davis (SIO)

NOAA Technical Contact: Steve Piotrowicz (OAR)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

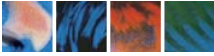
The SIO role in GODAE is to provide a direct link between Argo and other in situ ocean observational elements with the modeling and assimilation elements of the ECCO-GODAE consortium. The use of Argo float profiles is a major GODAE activity. As with any new data set, there are many issues to be confronted for successful use of the data, and the SIO responsibility is to provide the required knowledge of datasets and expertise with instrumentation. The SIO group also serves as an interface between assimilation activities and CLIVAR science. The ocean research carried out under CLIVAR involves three types of work with ocean data: (a) improvement in seasonal-interannual climate forecasting, including investigation of initialization of the ocean in forecast models; (b) interpretation of field process experiments focused on improving the representation in models of ocean processes; and (c) analyses of observed climate variability with an ocean focus on individual basins. Our goal is to use ocean state estimates (or ocean re-analyses) to explore the dynamical processes behind the observed variability.

Research Accomplishments

Elizabeth Douglass completed her Ph.D. dissertation, including data analysis and ocean data assimilation (ODA) using the ECCO model to study interannual variability in ocean circulation and heat and freshwater transport in the North Pacific Ocean. The results indicate a strong role for subsurface datasets in ODA modeling. The subsurface ocean is not adequately represented in the model unless constrained by subsurface data with appropriate weighting. Northward ocean heat transport during the 1990s had substantial interannual variability, amounting to about 50% of the mean. A strong maximum in northward heat transport in 1998 coincided with a minimum in air-sea heat exchange and therefore a maximum in heat storage.

D. Roemmich and J. Gilson have created a gridded version ($1^\circ \times 1^\circ \times$ monthly) of the global Argo dataset for the period 2004 – 2008. Gridded Argo climatologies such as this one will quickly replace historical climatologies for initialization of prognostic models as well as form comparison datasets for ODA models. That is, statistical (objective) interpolations of Argo data are a key yardstick for testing the realism of ODA results such as ECCO-GODAE. In some cases, climatologies are used to constrain the variability in assimilation systems, giving added motivation for use of modern rather than historical data.

Specialist J. Gilson continues to improve techniques for delayed-mode quality control of Argo data, and he participates in international efforts aimed at standardizing and optimizing the Argo dataset. Gilson's graphical user interface for Argo quality control has been widely adopted by international Argo. This work has great benefits for GODAE because it will provide a self-consistent and high quality Argo dataset suitable for GODAE.



SIO High Resolution XBT/XCTD Transects

Dean Roemmich, Bruce Cornuelle and Janet Sprintall (SIO)

NOAA Technical Contact: Mike Johnson (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

Research Objectives and Specific Plans to Achieve Them

The SIO High Resolution XBT Network is a set of basin-spanning shipping routes (Fig. 1) along which eddy-resolving temperature transects are collected four times per year. The HRX Network was initiated in 1986 along a commercial shipping route between New Zealand, Fiji, and Hawaii. It was subsequently expanded during the 1990s to include basin-spanning temperature transects in all of the oceans. Major partners in the HRX network include Scripps (Pacific and Indian Ocean), NOAA/AOML (Atlantic), and CSIRO (SW Pacific, Indian). Typically, each transect is repeated on a quarterly basis to resolve variability in temperature, geostrophic circulation and transport on annual and longer periods. Scientific objectives of the HRX Network are:

- Measure the seasonal and interannual fluctuations in the transport of mass, heat, and freshwater across transects which define large enclosed ocean areas.
- Determine the long-term mean, annual cycle and interannual fluctuations of temperature, geostrophic velocity and large-scale ocean circulation in the top 800 m of the ocean.
- Obtain long time-series of temperature profiles at precisely repeating locations in order to unambiguously separate temporal from spatial variability.
- Determine the space-time statistics of variability of the temperature and geostrophic shear fields.
- Provide appropriate in situ data (together with Argo profiling floats, tropical moorings, air-sea flux measurements, sea level etc.) for testing ocean and ocean-atmosphere models.
- Determine the synergy between HRX transects, satellite altimetry, Argo, and models of the general circulation. What are the minimal sampling requirements for in situ data?
- Identify permanent boundary currents and fronts, describe their persistence and recurrence and their relation to large-scale transports.
- Estimate the significance of baroclinic eddy heat fluxes.

Research Accomplishments

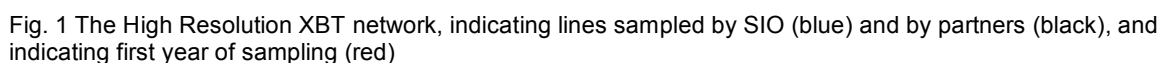
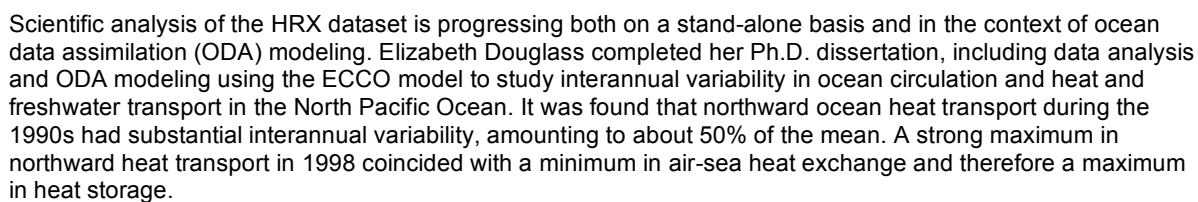
Quarterly HRX transects have been maintained along basin-spanning routes (Figure 1) that include:

- PX37/10/44 (North Pacific - San Francisco to Hawaii to Guam to Hong Kong)
- PX38 (North Pacific - Hawaii to Alaska)
- PX08 (South Pacific - New Zealand to Panama)
- PX06/31 (Central Pacific - New Zealand to Fiji to Los Angeles)
- PX30 (South Pacific - Brisbane to Fiji, joint with CSIRO Australia)
- IX15/21 (South Indian - Durban to Mauritius to Bass Strait)

Logistical assistance or XBT probes are provided collaboratively for:

- PX34 (South Pacific - Wellington to Sydney, CSIRO Australia)
- IX28 (Southern Ocean - Hobart to Antarctica, CSIRO Australia)
- AX22 (Southern Ocean - Drake Passage)

During each cruise, XBT temperature profiles (0-800 m) were collected at spatial intervals from 10 km near ocean boundaries and the equator, to 50 km in interior regions - resolving boundary currents and interior eddies for calculation of ocean-wide integrals of geostrophic transport. A web site for the project, with downloadable data, is maintained at <http://www-hrx.ucsd.edu>. HRX data are transmitted on the GTS immediately after collection for real-time applications. Due to the rapidly evolving nature of the present-day commercial shipping industry, a strong focus of the work has been to maintain sampling along routes as ships and shipping companies change.



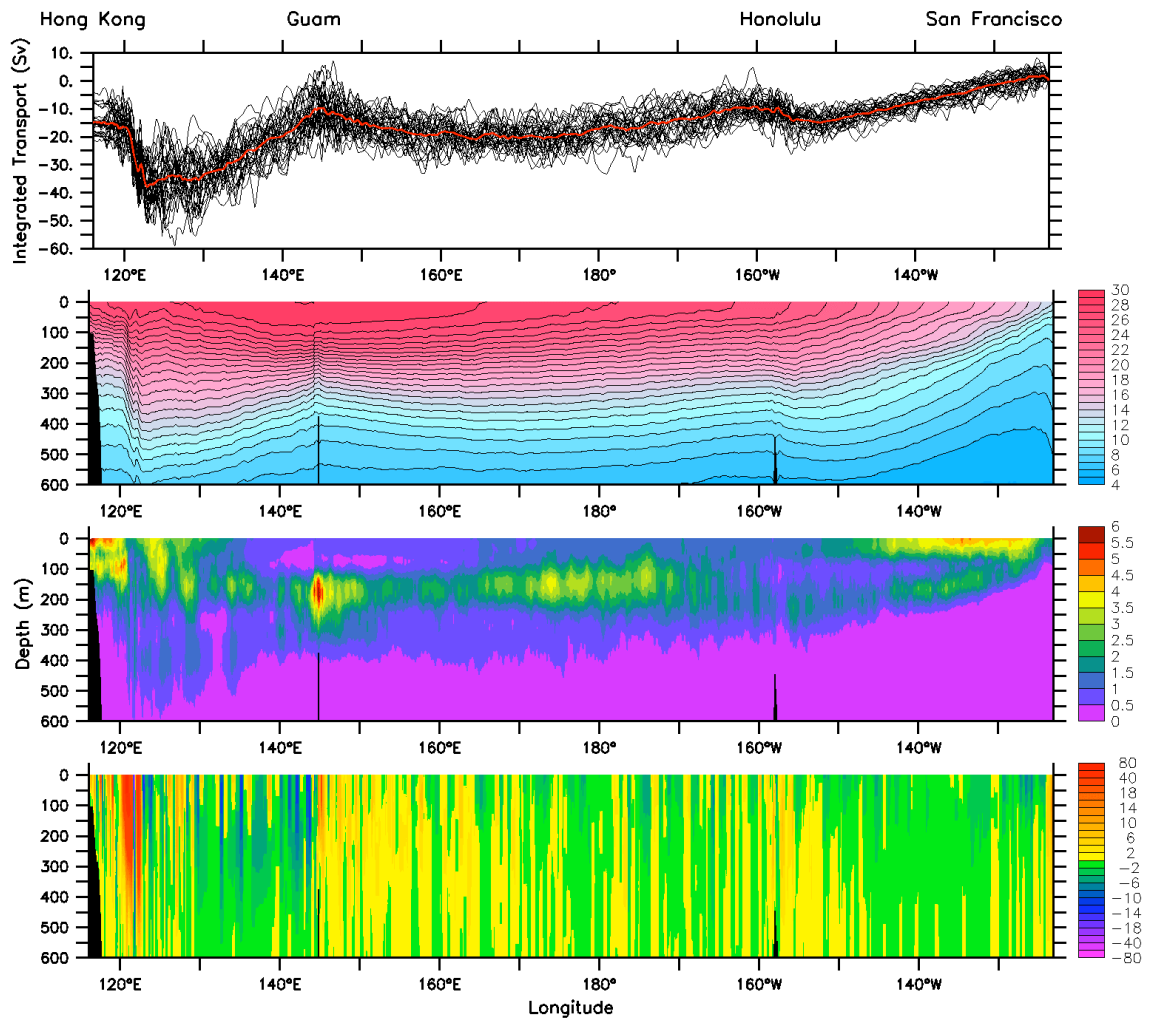


Fig. 2 HRX Line PX37/10/44: (top panel) integrated geostrophic transport for all cruises (black) and mean (red), 1992-2008. (2nd panel) mean temperature. (3rd panel) temperature variance. (4th panel) mean geostrophic velocity across the ship track



Meridional Overturning Variability Experiment (MOVE)

Uwe Send (SIO)

NOAA Technical Contact: Mike Johnson (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

A present gap in the sustained ocean climate observing system are techniques and programs for monitoring the circulation and mass/heat/freshwater transports of major current systems, sometimes called "transport reference sites." For broad-scale and deep-reaching circulations, a recently demonstrated method consists of fixed-point installations with moored and bottom-mounted instruments to obtain horizontally and vertically



integrated measurements throughout the water column. The MOVE project now maintains the developed elements of the first such system by having taken over operation of a moored transport array in the Atlantic. This had been operated via the German CLIVAR programme from 2000 to 2006 in the subtropical west Atlantic along 16N, in order to observe the transport fluctuations in the North Atlantic Deep Water layer.

With the NOAA MOVE project, SIO/JIMO/NOAA will operate the two geostrophic endpoint moorings between the western boundary and the Mid-Atlantic Ridge (yielding dynamic height and bottom pressure differences), plus a small current meter mooring on the slope. This is complemented on the eastern side of the Atlantic with a German-funded and operated mooring (near the Cape Verde islands). In the first years of the NOAA MOVE project, the acquisitions for complete configuration of the moorings will take place, and the array will gradually be built up to its full implementation. In later years, routine operation will be achieved, and routine delivery of indicators about the state of the thermohaline overturning circulation at this latitude will be enabled.

Research Accomplishments

In the reporting period preparations took place for the mooring service cruise that had been planned for May 2008. Additional instruments were purchased since the previously deployed moorings still contained borrowed equipment from Germany (current meters, microcats) and from other groups at SIO (acoustic releases, beacons). Also, sufficient spare sensors for one complete mooring had to be acquired, since the new cruise would visit each mooring site only once, necessitating mooring recovery and re-deployment within a 24hr period at each location. That means that a complete mooring with sensors needs to be at hand when arriving at a site. After that, the recovered sensors could be recycled/rotated for the next mooring deployment. Additional PIES were also purchased since spare ones need to be at hand during a cruise, in case of failure of previously deployed ones (this turned out to be necessary at one site during the cruise executed in 2008).

Mechanical problems with the scheduled ship (*R/V Ron Brown*) lead to cancellation of the joint MOVE/NTAS cruise few weeks before its scheduled departure from Barbados. A replacement cruise was finally arranged on the WHOI vessel *Oceanus*, from Woods Hole to Barbados, 14-31 July 2008. This resulted in extra shipping, rush/airfreight, and overlap with other activities requiring purchases of duplicate equipment and borrowing and flying deck equipment back and forth. The cruise was very successful ultimately. 36 microcats were recovered with 100% data return, and also deployed again, with high precision calibrations in between. 7 old mechanical current meter (borrowed from Germany) were recovered, of which 5 had worked completely. They were replaced on the new moorings with 7 borrowed mechanical current meter from France and Germany, plus 7 new acoustic Aquadopp current meter purchased from MOVE funds. After this 1-year inter-comparison period, only the acoustic current meters will be used in the future. These and all microcats have inductive data telemetry capability. This is not currently being exploited but is an intended upgrade path for future MOVE years for telemetering MOVE data in real-time.

Of the 3 PIES (inverted echosounders with pressure sensors) on the MOVE section, one was found to have a (known) transducer problem. It was still functioning, but the acoustic data download was intermittent. An additional PIES was therefore deployed next to it in the same location. The other 2 PIES were found to work well and complete data sets were downloaded acoustically. The cruise ended just prior to preparation of this report, and the data are currently being processed, to yield another 15 months of transport data from the MOVE section. This will bring our total deep transport record to 8 years in length.

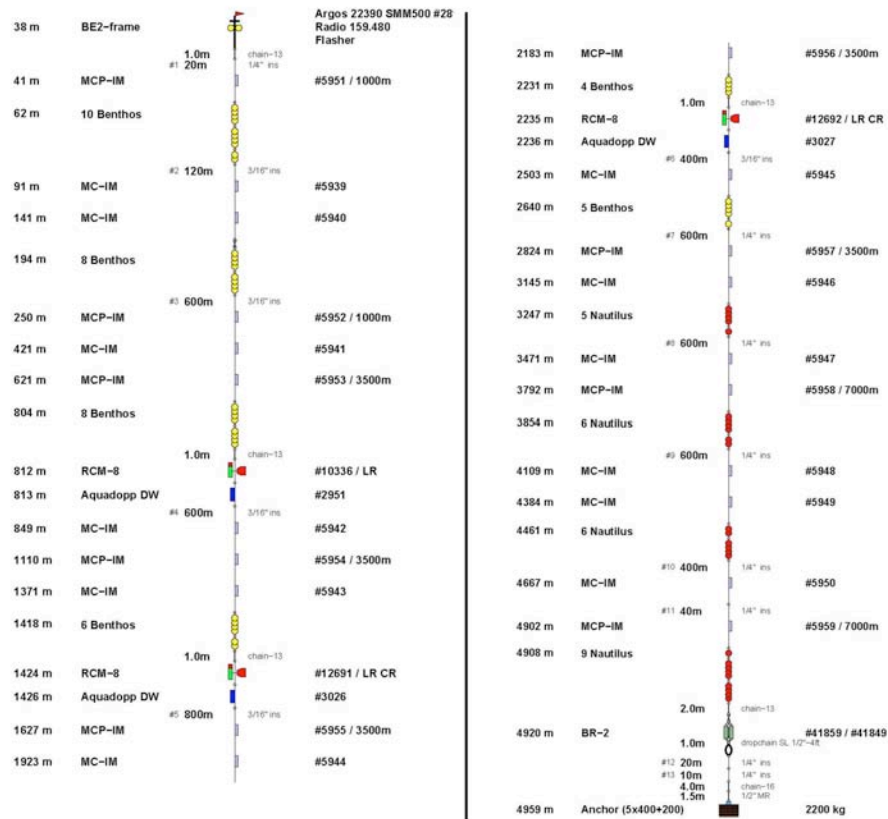


Fig. 1 Diagram of the western 5000m long MOVE mooring, carrying 21 microcat sensors and 6 current meters, as deployed in July 2008

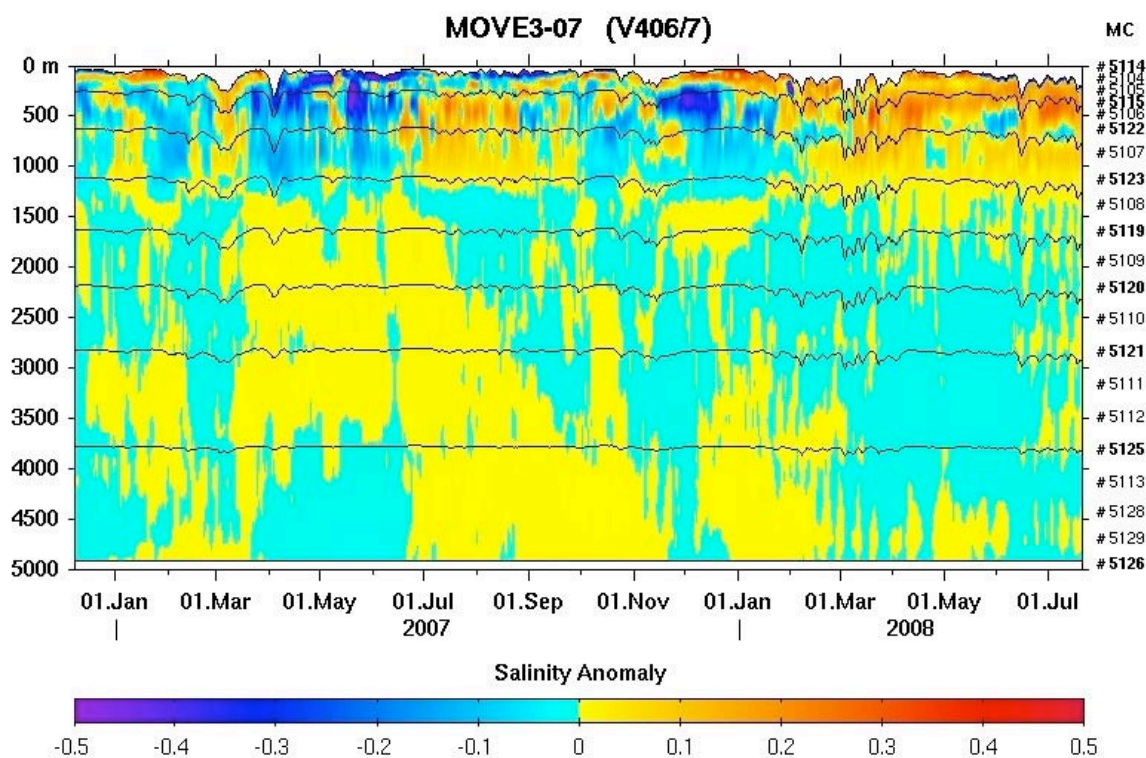


Fig. 2 15-month time series of salinity anomaly from the 21 microcats on the western MOVE mooring recovered in July 2008



Scripps Experimental Climate Prediction Center (ECPC)

John Roads (SIO)

NOAA Technical Contact: Kenneth Mooney (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The goal of the Experimental Climate Prediction Center (ECPC) is to develop an integrated, global to regional, climate prediction capability. ECPC undertakes research to:

Identify coupled modes of interannual variability

Persistent surface anomalies in the ocean and land have a strong influence upon atmospheric features that would otherwise be unpredictable beyond a few weeks.

Develop models capable of predicting these modes

Experimental state of the art numerical models are being acquired from national centers (e.g. National Centers for Environmental Prediction) as well as being developed within the ECPC.

Evaluate the predictive capability of these models

Experimental predictions are made, routinely, to evaluate how well these numerical models can predict at various time scales ranging from days to years. As these predictions are evaluated, experimental predictions are posted to the world-wide-web for download by interested researchers.

Transfer ECPC methodologies to other application centers

ECPC collaborates with researchers at a number of regional application centers to transition experimental prediction methodologies to operation.

ECPC emphasizes research leading to routine experimental predictions, applications, and products with an integrated modeling system that fully couples the atmosphere, land, and ocean at global to regional scales.

Research Accomplishments

During the past year, we continued experimental forecasts using the latest ECPC G-RSM. Two suites of forecasts are performed, one initialized from the NCEP analysis, and the other initialized from previous runs forced by observed SSTs. Both forecasts are posted on the web site <http://ecpc.ucsd.edu>. For the latter forecast, a 12-member 7-month forecast using predicted SSTs and a 10-member 4-month forecasts using persisted SSTs are used. In addition we run a 12-member 3-month downscaling over the western U.S. using 35km resolution RSM, which is supplemented by the ensemble AMIP-style integration for constructing skill maps. We examined the relation between the number of ensembles and the forecast skill. It is found that the skill generally increases as the number of ensemble increases, but only when the skill of small ensemble member is high (Figure 1). This finding has a potential of economizing the ensemble integration. As an alternative to ensemble downscaling, we tested a method to choose one member which is closest to the ensemble average, and downscaling this one case. This method provided reasonably accurate downscaling for the transition season.

As requested by the USFS, our short-range climate forecast system is now being focused on 4 month forecasts made at the beginning of each month along with corresponding historical runs made for the corresponding months from 1982-present. Global and regional historical simulations are being run to better understand the model capabilities. We are contributing these simulations to regional model comparison projects in order to better understand the capabilities of our G-RSM.



The evaluation of the cloud water and cloudiness forecast parameterization by Iacobellis and Somerville (2000) using 10-member ensemble 50-year AMIP style integration is complete. Unfortunately, comparison of the skill showed that the new model is slightly less skillful than the control, and considering the computer overhead of 50%, we were forced to abandon the implementation of the new model. However, the new scheme is extensively used in the RSM for regional downscaling, due to its better performance and reduction in positive precipitation bias. We have started more basic research on the marine stratocumulus using high resolution visible channel of the GOES satellites. This study allowed for the first time, high frequency variability of stratocumulus clouds over the eastern Pacific. Very interesting changes in the second moment characteristics of low clouds, such as the skewness and kurtosis are revealed. The relation between large scale atmospheric parameters and cloud properties are also examined.

We confirmed that the introduction of Scale Selective Bias Correction was shown to significantly improve the downscaling simulations of climate time scale. The scheme is applied to make downscaling over the globe, as well as to perform data assimilation of stable water isotope. We also developed a new incremental interpolation of the global forcing field used to force the RSM. This method allows the use of coarse resolution forcing at standard pressure levels for reasonably accurate downscaling (Figure 2), making it possible to perform many more downscaling not possible before. Using these techniques, we started to prepare for a semi-operational downscaling of NCEP CFS. We are also working on running Regional Ocean Modeling System (ROMS) over the coast of California to eventually perform coupled downscaling of CFS. The Scripps Coupled Ocean-Atmosphere Regional (SCOAR) based on ROMS has also been extensively tested over various parts of the world ocean for this purpose. The 20-year atmospheric downscaling over extended California coastal region (CaRD10V2) has been completed. This product will be extensively used as a basic dataset to test the configuration of ROMS and predictability over the area. The comparison with other notable regional models, such as RegCM, MM5 and WRF, showed that the RSM performance was one of the best.

We have updated our ocean forecast and fisheries outlook forecast using initial conditions from May 2008. These initial conditions are from JPL's ocean data assimilation effort, b) built a high resolution (6-8km) grid of the Southern California area. We have completed a 50-year long climate run and successfully performed a data assimilation test.

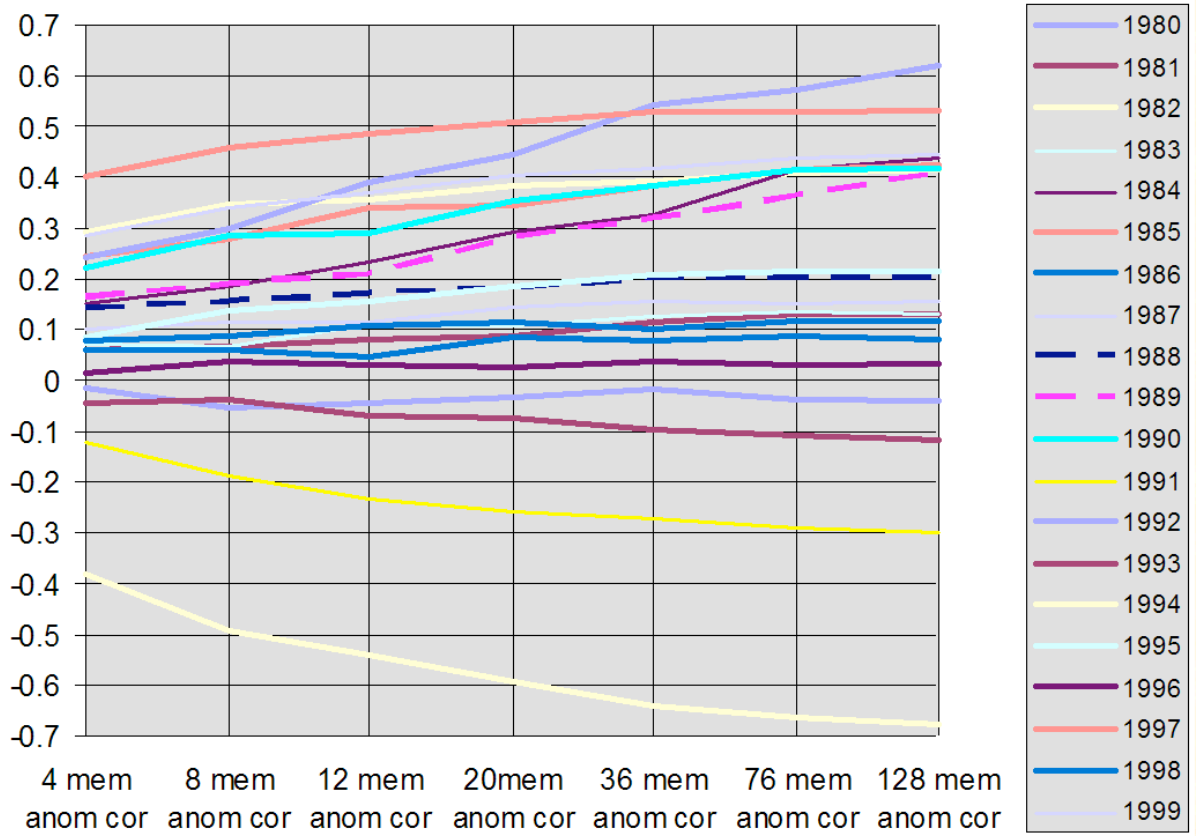


Fig. 1 Skill versus number of ensemble members. The skill is computed from anomaly correlation of 500hPa height over the PNA region. Forecast length varies from 1-4 months to 5-7 months

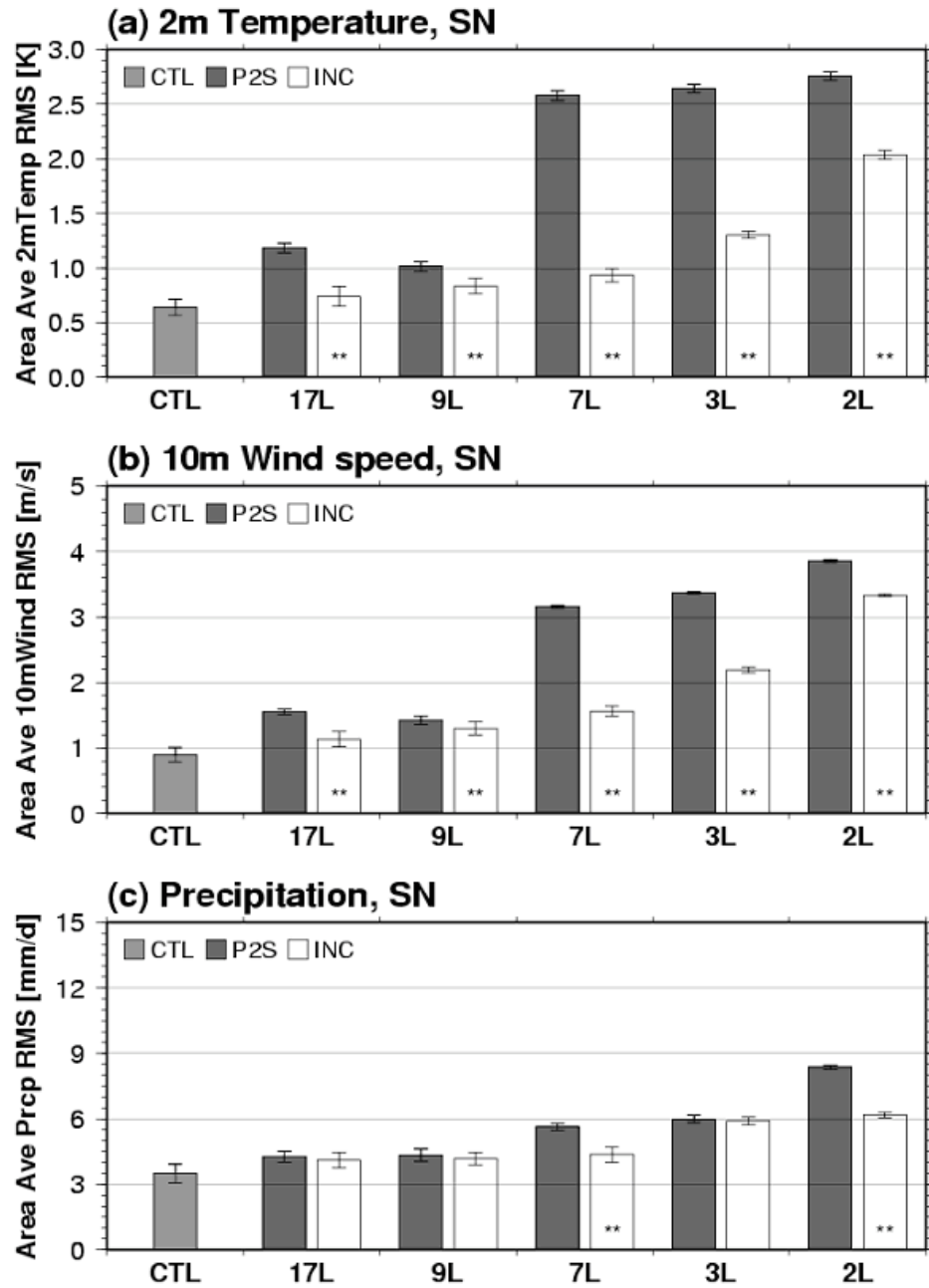


Fig. 2 Ensemble means of area averaged RMS between CTL (an experiment with full sigma level forcings) and experiments with different number of vertical levels used as forcings are shown for 2-meter air temperature (a), 10-meter wind speed (b) and precipitation (c). Experiments are performed with the Scale Selective Bias Correction. Dark gray and white bars denote the use of a simple vertical interpolation (P2S) and the incremental interpolation (INC) for the forcings. Light gray bars indicate RMS between the CTL ensemble members. The error bars indicate standard deviations of the RMS of ensemble members and one and two asterisks (*) denote the 95% and 99% significance levels of the difference from the same P2S experiments



Seasonal Climate Forecasts for Firedanger Applications

John Roads (SIO)

NOAA Technical Contact: Ming Ji (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The Scripps Experimental Climate Prediction Center (ECPC) has been making experimental, near real time, weekly to seasonal, global to regional fire danger forecasts for more than 10 years. US fire danger forecasts and validations are based on standard indices from the US Forest Service National Fire Danger Rating System (NFDRS), which include the: Ignition Component (IC), Energy Release component (ER), Burning Index (BI), Spread Component (SC), and the Keetch Byram drought index (KB). The Fosberg Fire Weather Index (FWI), which is a simplified form of the BI, has been previously used not only for the US but also for other global regions and is thus included for comparison. As shown previously, all of these indices can be predicted well at weekly times scales and there is even skill out to seasonal time scales over many US West locations. The most persistent indices (BI, ER, and KB) tend to have the greatest seasonal forecast skill. The NFDRS indices also have a relation to observed fire characteristics such as fire counts (CN) and acres burned (AC).

The goal of our current research has been to further develop these seasonal firedanger forecasts by using the recently developed seasonal NCEP global and regional CFS/RSM forecast ensembles to drive the fire danger code. From this work, we have significantly improved the utility of currently experimental firedanger forecasts for the USFS and other communities such as the National Interagency Coordinating Committee, which are dependent upon long-horizon forecasts for resource allocation planning but have had to previously adapt to standard climate prediction output (Temperature and Precipitation), which are not necessarily well-suited to fire danger forecast needs.

Research Accomplishments

It has been commonly assumed that forecasts of standard monthly mean temperature and precipitation could be provided by the forecast community and that the fire danger application community, which actually needs forecasts of other meteorological features, such as relative humidity, windspeed, and subsurface and vegetation moisture in addition to temperature and precipitation, would somehow adapt to using only the standard forecast variables. Here we have shown that it is quite possible to make dynamical seasonal fire danger forecasts fully compatible with what the fire danger applications community need (daily to seasonal forecasts of temperature, relative humidity, wind speed, precipitation) which can then be used to drive initializing/validating and forecast FDI. We are also attempting to provide additional circulation variables such as 500 and 1000 mb height and surface pressure anomalies.

Confirming the previous pilot experiment it was found here that there is significant seasonal forecast skill for all of the standard Fire Danger Indices (FDI; Ignition component, Burning Index, Energy Release Component, Keetch Bryam Drought Index, Spread Component) as well as the Fosberg Fire Weather Index, which had previously been used to forecast global fire danger. Persistence forecasts were also evaluated for comparison to the forecast FDI. It was also shown that the FDI were somewhat better related, than the input meteorological values, to fire statistics such as fire counts and acres burned.

Still, the local forecast relationships are certainly weaker than the correlations with the FDI validation and further improvements in forecast skill should still be possible. We suspect that the major reason that the initializing validating fire danger had a high degree of correlation with observed fire characteristics is due to our use of observed rather than forecast precipitation. In turn, we suspect that the major decrease in forecast skill is due to the loss of skill in predicting precipitation, although the loss of skill from the forecast of other variables must also contribute.

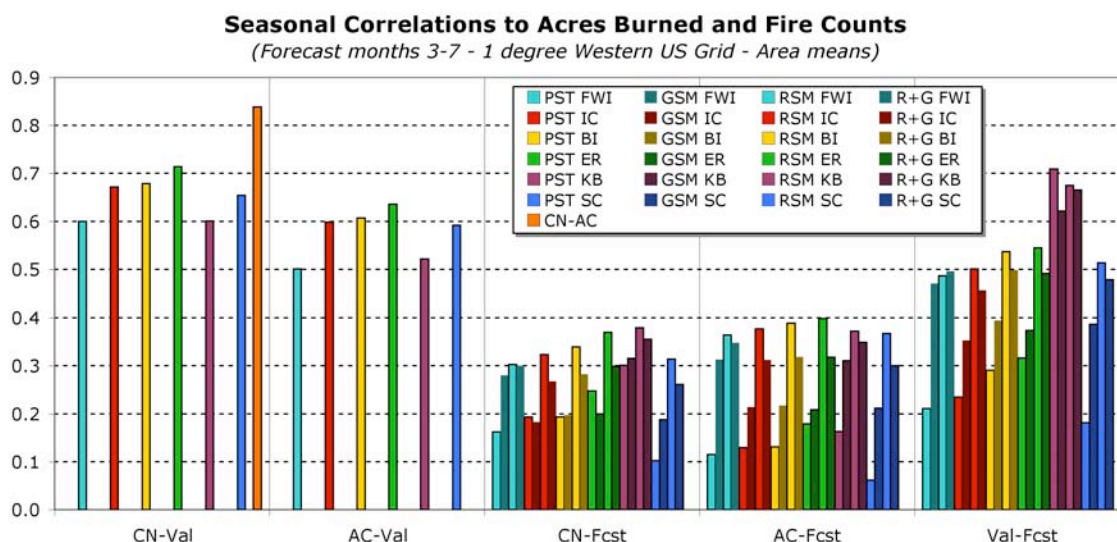


Fig. 1 3-7 month seasonal FDI forecast correlations with FDI validations, CN, and AC. Also shown are the correlations of the FDI validations with the CN and AC. Forecasts include persistence of the initial day (PST), GSM, RSM, and the average of the RSM and GSM (R_G). FDI include FWI, IC, BI, ER, KB, SC

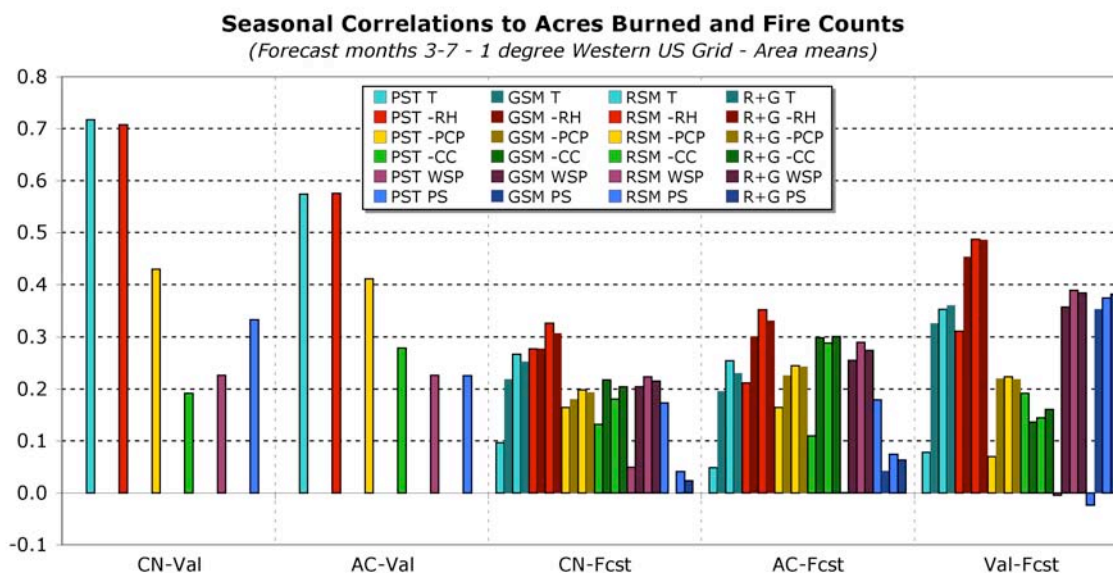


Fig. 2 3-7 month seasonal MV forecast correlations with meteorological variable validations, CN, and AC. Also shown are the correlations of the MV validations with the CN and AC. Forecasts include persistence of the initial day (PST), GSM, RSM, and the average of the RSM and GSM (R_G). MV include T, -RH, -Pc, -CC, WSP, Ps



Economic Benefits of Weather and Climate Forecasts to California Energy Production Management

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NOAA Technical Contact: Ming Ji (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

Research Objectives and Specific Plans to Achieve Them

This project evaluates the potential for using climate forecasts to help manage the joint water and energy resources of the western U.S. Regional hydrologic forecast models are used in management of hydroelectric power resources in California and the Columbia River basin of the Pacific Northwest (PNW); however, these rarely incorporate climate predictions. Instead they use midwinter snow pack measurements, and so have no skill beyond climatology prior to midwinter. Furthermore, these methods have generally been applied at local rather than regional scales. Rudimentary models are used to predict effects of weather on the energy industry, but these existing methods use climate forecasts in only a very crude way or not at all. Furthermore, little or no effort has been made to jointly predict both water and energy variations across the West on seasonal time scales; addressing both in an integrated way is a unique feature of this project. Joint prediction of water and power generation potential is critical, given the large role hydroelectric power plays in the economy of the western states. Consideration of both California and the Pacific Northwest is also critical because these regions exchange power; for instance, a winter drought in Washington can affect the subsequent summer exports of hydroelectric power to California for air conditioning. In summary, this project will take an integrated look at climate, water, and energy throughout the western U.S. to evaluate the usefulness of seasonal climate prediction in operational management of western water and energy resources.

This project as proposed enumerated four objectives defined as follows:

Task 1: Document how variations in climate affect energy supply and demand in the U.S. west

Task 2: Create and evaluate the skill of climate forecasts predicting those aspects of climate variability found in Task 1 to most affect energy supply and demand

Task 3: Analyze the effect that the predictable part of the climate variability has on the western U.S. energy system

Task 4: Work with energy utility and public sector decision makers to see how climate forecasts could be used to optimize operations

Research Accomplishments

Sponsored research has been completed and manuscripts for peer-reviewed publications are being drafted. We developed robust statistical models relating western US peak daily electrical loads to maximum daily temperature. We found that previously published seasonal statistical forecast models for temperature were ill-suited to energy sector management applications because they forecast a single mode of the distribution of possible temperatures, which did not allow for construction of daily timestep temperature scenarios with associated probabilities. These models are difficult to fine tune for users with proprietary information regarding critical temperature thresholds. We addressed these needs by developing experimental seasonal forecasts of daily maximum temperature distributions. Runs of high temperatures (especially of nighttime temperatures) are particularly important for energy demand, and we analyzed the climatology of recent extreme heatwaves in California in order to understand their potential forecastability.

Because regional hydropower resources are an important source of cheap, flexible energy generation during peak demand periods, the coherence of water surplus/deficit conditions across the region's hydrologic basins is an important consideration for energy sector planning. We found that surplus/deficit conditions have become



much more coherent across the Columbia, San Joaquin-Sacramento, and Colorado basins in recent decades, limiting the reliability of this energy source. We partnered with CA DWR to analyze streamflow forecast skill and utility for DWR management objectives.

COMPOSITE ANOMALY MAPS – CALIFORNIA HEAT WAVES

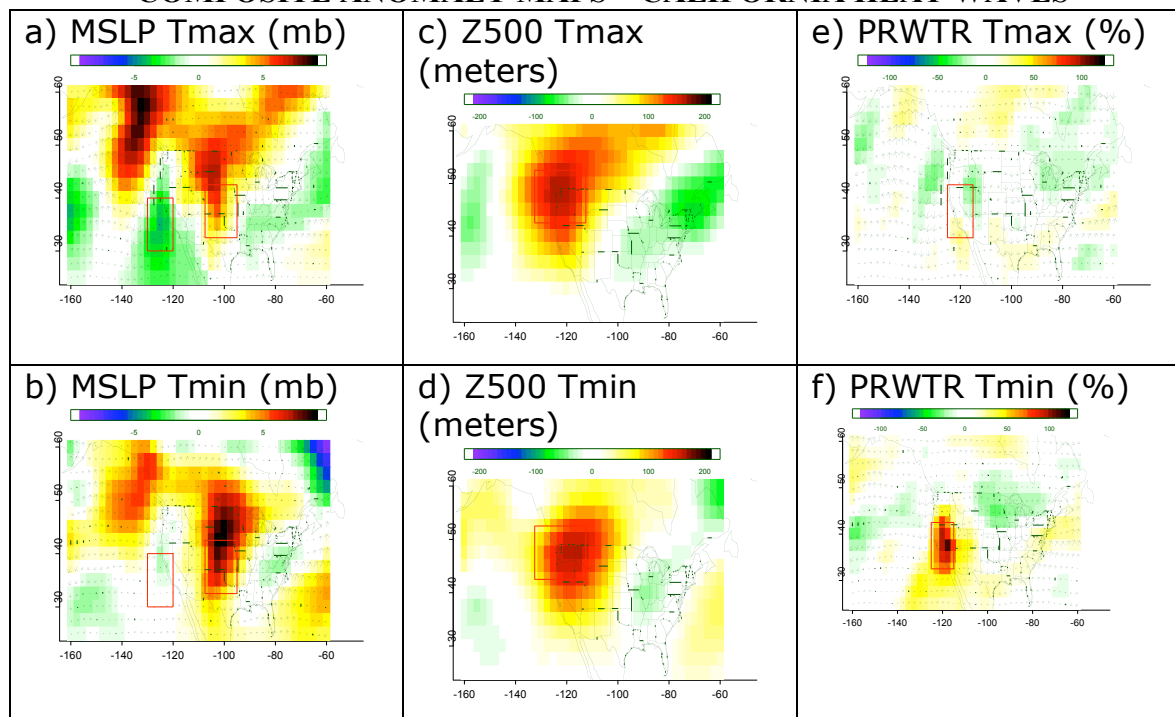
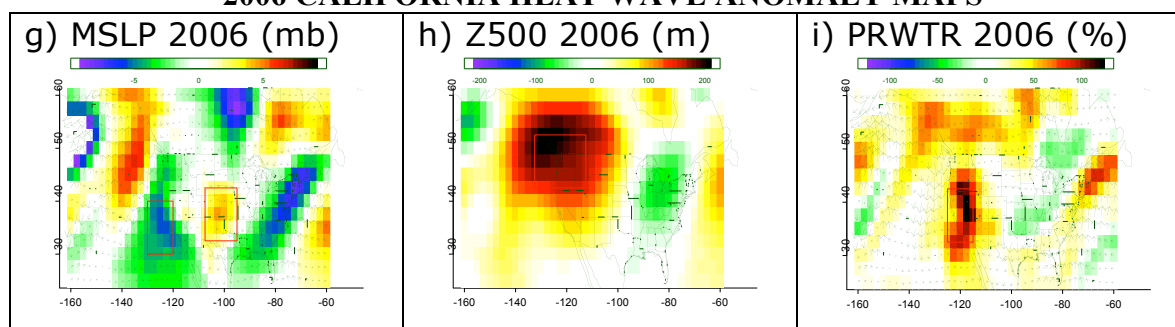


Fig. 1 Surface circulation (wind at sigma level 995) and mean sea level pressure in millibars (a,b), 500mb geopotential height in meters (c,d), and precipitable water in percent of normal content (e,f) anomalies with respect to JJA mean. Anomalies are composited for the peak days of the largest five daytime events (a,c,e) and the largest five nighttime events (b,d,f) excluding 2006 and 1972. The data are from the NCEP/NCAR Reanalysis I (Kistler et al. 2001).

2006 CALIFORNIA HEAT WAVE ANOMALY MAPS



July 23 2006 anomalies of MSLP and wind at 995 sigma level (g), 500m geopotential height (h), and precipitable water (i). Units are the same as above

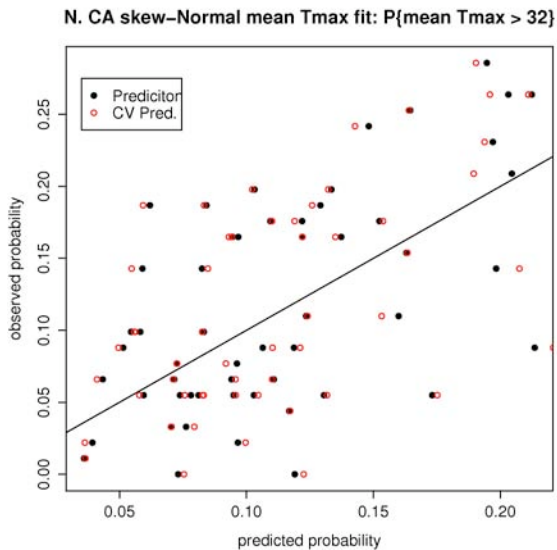


Fig. 2 Forecast (black dots) and Cross-validated forecast (red dots) probability of exceeding 32 degrees Celsius maximum daily Temperature (averaged over Northern California) versus observed probability of exceeding 32 degrees Celsius, 1950 - 2003



Regional Aerosol-Chemistry-Climate Observatories for the Indo-Asia-Pacific Region (Project Atmospheric Brown Cloud) and the Maldives Autonomous UAV Campaign (MAC)

V. Ramanathan (SIO)

NOAA Technical Contact: Howard Diamond and Chester Koblinsky (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

About 60 percent of the world's population of six billion lives in Asia. Environmental consequences of Asia's rapid economic development can be far reaching, especially with respect to air pollution at local and regional levels. A recent international study, the Indian Ocean Experiment (INDOEX), documented the vast extent of the so-called Asian haze, a 3 km thick brownish layer of pollutants hovering over most of the tropical Indian Ocean, South, Southeast and East Asia. The haze particles consist of sulfates, nitrates, organics, black carbon and fly ash amongst several other pollutants, which can be transported far beyond their source region, particularly during the dry season. Potential direct and indirect consequences of the haze involve regional and global climate change, impacts on ecosystem, the water cycle, agriculture and human health. Significant reduction in the solar radiation reaching the surface; a 50-100% increase in solar heating of the lower atmosphere; rainfall suppression; agricultural productivity decline; and adverse human health effects. Preliminary results also indicate that the build up of the haze, a mash of ash, acids, aerosols and other particles, is disrupting weather systems including rainfall and wind patterns and triggering droughts in Western parts of the Asian Continent. The regional and global impacts of the haze are set to intensify over the next 30 years as the population of the Asian region rises to an estimated five billion people.

Since the regional and temporal scales of the pollution layer are not well known, high quality data on the haze and precursor pollutants is urgently needed to assess the long-term trends. There is also a need to find the answers to the following basic questions: What are the sources of the soot and the other major haze components? How are the aerosol particles transported, transformed, and ultimately removed from the



atmosphere? How does the solar heating in the haze affect the monsoon rainfall? How does the reduction of solar energy to the surface affect the water budget and soil moisture? Does the haze amplify or ameliorate the warming due to greenhouse gases? Before policy issues can be rationally addressed, these questions need to be answered.

A project called Atmospheric Brown Cloud (ABC) has been initiated jointly by UNEP and the Center for Clouds, Chemistry and Climate (C4) at the Scripps Institution of Oceanography (C4/SIO). Under Project ABC scientists plan to establish a network of ground-based monitoring stations throughout Asia to study the composition and seasonal pattern of the haze. UNEP has pledged to facilitate and assist with science, research and capacity building program and bring the results to attention of governments. The U.S. observation program in ABC has been funded by NOAA since 2002. Starting in 2004, SIDA, the Swedish International Development Cooperation Agency is providing funding support to UNEP for the implementation of ABC Capacity Building and Impacts Assessment. The website <http://www-abc-asia.ucsd.edu> offers a complete and current description of Project ABC and related programs.

Research Accomplishments

Since 2006, the US component of Project ABC, which is funded by NOAA and is being reported here, has started to introduce the concept of vertical observatory deploying instrument onboard unmanned aircraft to supplement ground observations. This annual report summarizes the current developments in US ABC UAS program. In addition, starting January 2007, the daily operations of the Maldives Hanimaadhoo super-site and the Nepal ABC observatory have been transferred to UNEP-Bangkok while the US ABC program focuses in in-depth study in the effects of ABC on climate, regional water cycle. Included in this report is a summary of the first part of that study which will be released by UNEP later this year.

Direct and Diffuse Components of Global Solar Radiation at the Surface and Their Dependence on Aerosol Properties

In modeling photosynthesis, it is important to discriminate between the direct and diffuse components of incoming global solar radiation. ABCs alter the proportion of diffuse radiation in global solar radiation reaching the Earth's surface. Empirical relations are presented for clear skies to estimate the share of both components from global solar radiation and aerosol optical depths (AOD) measurements. In these relations, the share of diffuse component from global and direct radiation is related to the ratio between the AOD and the solar zenith angle. These relations are based on aerosol and radiation measurements at the Maldives Climate Observatory at Hanimaadhoo (MCOH) in the Republic of Maldives. The observatory (6.776°N, 73.183°E) was established in October 2004 as part of Project ABC. Diffuse fraction (diffuse to global flux ratio) varies from 0.1 to 0.65 (10-65 per cent) during the winter and pre-monsoon seasons and from 0.09 to 0.35 (9-35 per cent) during the monsoon and post-monsoon seasons. Direct to diffuse flux ratios vary from 0.5 to 8.0 during the winter, whereas during the post-monsoon they vary from 1.8 to 10.0. In addition to these observations, the validated radiative transfer model with input from MCOH data for aerosols, water vapour and ozone, is used to investigate the modification of clear-sky diffuse, direct and global irradiances (broadband and visible regions) by ABCs as a function of the solar zenith angle. The surface-reaching global fluxes are decreased by 2-70 per cent, depending upon the AOD, single scattering albedo and the solar zenith angle. The method presented in this chapter is particularly useful for application in crop growth models.

California Air Pollution Profiling Study (CAPPS)

Measuring aerosol and gas phase pollutants at the surface level only provides partial information for both climate and air pollution studies. Information on the vertical distribution of these species is important for properly answering questions concerning such issues as transport and radiative forcing. The California AUV Air Pollution Profiling Study (CAPPS) routinely measures the vertical distribution of aerosol particles and ozone using small, light-weight unmanned aerial vehicles equipped with miniaturized instrumentation. The study builds upon experience gained during the Maldives Aerosol Campaign (MAC) in 2006 and utilizes much of the same equipment.

The missions consist of the automated aircraft performing measurements from the surface level (2200 feet/700 m) to 12000 feet/3800 m. Flights were started in April and have occurred at roughly one-month intervals. The project is scheduled to collect data through December 2008 to demonstrate the value and utility of unmanned aircraft being deployed as a vertical component of a climate observing system consisting of ground station, unmanned aircraft and satellite observations. This concept will be later proven at the ABC Gosan Superstation in Jeju, Korea in which 3 UASs will be deployed to measure, in conjunction with a ground intensive field program, the unprecedented mandatory emission reduction in Beijing during the 2008 Summer Olympics.



The Pacific UAS Testbed – Atmospheric Rivers

The US ABC Program is collaborating with NOAA's Unmanned Aerial Systems (UAS) Program to explore the capabilities of small unmanned aircraft to support and enhance NOAA's scientific projects. As part of that program, Scripps and NOAA teamed up for a project in the NOAA's Pacific UAS Testbed, with the goal to improve the understanding and forecast of landfalling storms. Within these storms, narrow regions of high water vapor content exit—so-called atmospheric rivers—that are responsible for transporting large amounts of water vapor from the tropics to the mid-latitudes. When reaching the West coast of the United States, these systems often cause intense rainfall and flooding.

To improve our understanding of these systems, a major field experiment has been tentatively planned for 2010, which will combine observations from ships, satellites, dropsondes, manned and unmanned aircraft. C4/SIO Manta UASs will be utilized to take detailed measurements of the vertical and horizontal structure of the atmospheric rivers. Specifically, the already developed instrumentation will be deployed to obtain measurements of temperature, humidity, as well as cloud and aerosol microphysical properties.

Another aspect of this study is to perform a water vapor budget study in atmospheric rivers. As part of this study, a Manta UAS will fly at low altitudes between 100 and 300 ft to take high-frequency measurements of the wind velocity and water vapor density, which will be used to derive the surface moisture flux. For this purpose, new instruments were purchased and modified, and are currently being tested.

Some findings of the capstone study on the effects of ABC in Asia:

The following 13 mega city ABC hotspots in Asia have been identified: Bangkok, Beijing, Cairo, Dhaka, Karachi, Kolkata, Lagos, Mumbai, New Delhi, Seoul, Shanghai, Shenzhen and Tehran

Five regional ABC hot spots around the world have been identified: i) East Asia (Eastern China, Thailand, Vietnam and Cambodia); ii) Indo-Gangetic Plains in South Asia (the North West to North East region extending from Eastern Pakistan, across India to Bangladesh and Myanmar); iii) Indonesia; iv) Southern Africa extending southwards from sub-Saharan Africa into Angola and Zambia and Zimbabwe; v) the Amazon basin in South America

The TOA forcing due to the increase of GHGs from the pre-industrial to the present is estimated by IPCC-AR4 (2007) to be about 3 Wm^{-2} (10% confidence interval of 2.6 to 3.6 Wm^{-2}). The same report estimates aerosol forcing (direct plus indirect) to be -1.2 Wm^{-2} (10% confidence interval of -2.7 to -0.4 Wm^{-2}).

The combined GHGs and ABC forcing is 1.8 Wm^{-2} with a 10% confidence interval of 0.6 to 2.4 Wm^{-2} . By comparing this with the GHGs only forcing of 3 Wm^{-2} (10% interval of 2.6 to 3.6 Wm^{-2}), it is seen that aerosols in ABCs have masked 20% to 80% of the GHGs forcing of the last century.

The ABCs induced atmospheric solar heating and surface dimming are large over Asia in general and over India and China, in particular. Annual mean solar heating of the troposphere increased by 15% or more over China and India; The heating increase in the lower atmosphere (surface to 3 km) where ABCs are located is as much as 20% to 50% (6 to 20 Wm^{-2}) over China and India. Large increases in heating rates were also noted in wide spread regions in the Northern Indian Ocean the western Pacific Ocean. Over China and India, the annual mean surface dimming due to just direct ABC forcing is about 14 to 16 Wm^{-2} (about 6%).

Over both China and India, large changes in solar radiation, surface and atmospheric temperatures and monsoon rainfall have been observed, and these changes cannot be explained solely from the increase in GHGs. Global Climate Model (GCMs) studies suggest that a combination of GHGs and ABCs along with natural variability are required to properly simulate the observed trends.

The ABC solar heating (by black carbon) of the atmosphere is suggested to be as important as GHG warming in accounting for the anomalously large warming trend observed in the elevated regions.

Decrease of reflection of solar radiation by snow and ice, due to black carbon deposition is emerging as another major contributor to the melting of the snow packs and glaciers. Recent ice core observations reveal large deposition of sulfates and black carbon and furthermore with a large increasing trend during the last few decades. Furthermore, new atmospheric observations in elevated regions of the Himalayas (from 1 km to 5 km) by the ABC project, within 100 km the Mt Everest region, suggest large concentrations of BC ranging from few hundred to a few thousand ng m^{-3} .

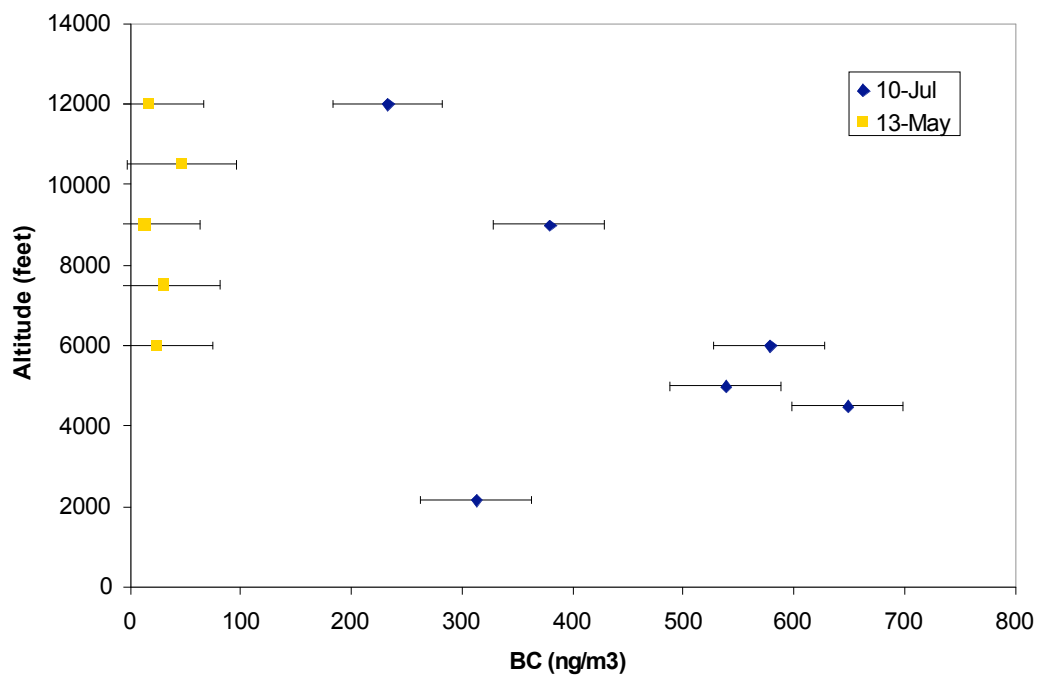


Fig. 1 California Hot Summer: Data collected by instrument onboard unmanned aircraft, measured black carbon over NASA Dryden before (May 13, 2008) and during wildfire events in California during 2008 (Courtesy V. Ramanathan and C. Corrigan)



The Himalyan-Tibeian Region is surrounded by ABCs and Dust

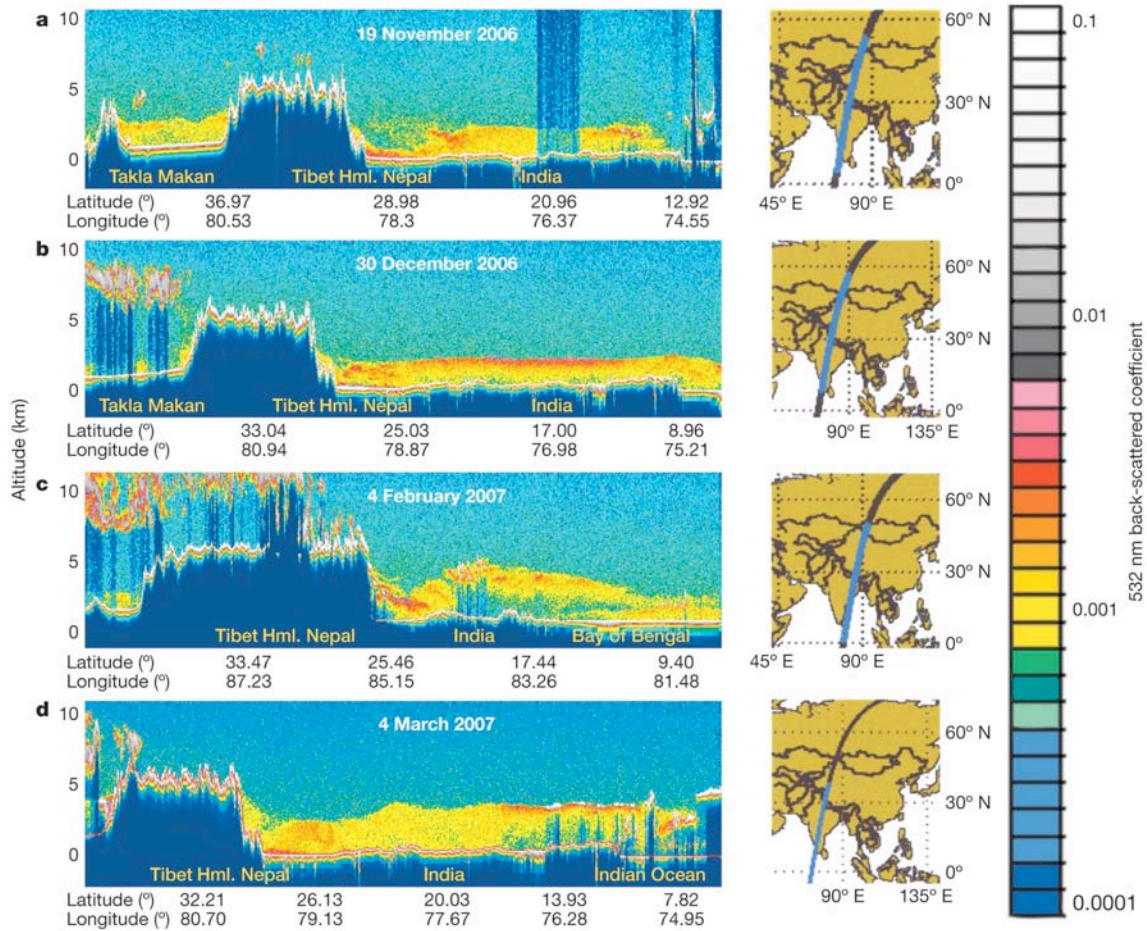


Fig. 2 Color-coded profiles of 532nm backscatter return signal from the CALIPSO lidar showing the vertical distribution of ABCs. The panels on the right show the orbit track across Asia and on the left the vertical extent of the aerosol is shown for the blue-shaded portion of each track. We chose the color scale so that aerosol usually shows up in green, yellow and red (for low, medium and high loadings, respectively) and boundary layer clouds usually show up as grey or white. Cirrus usually ranges from yellow to grey. Sample profiles are shown for four months of the dry season that extends from November to May. The Takla Makan desert is in northwestern China between 37°N and 41°N and 77°E to 90°E. Hml., Himalyas (*Ramanathan et al., 2007*)



Global Model Investigation of Warm Season Precipitation for North American Monsoon Experiment

Guang Zhang (SIO)

Technical Contact: Jin Huang (CPO/CPPA)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond



Research Objectives and Specific Plans to Achieve Them

1. To improve the GCM simulation of the North American monsoon system.
2. To simulate the diurnal cycle of monsoon convection and understand its relationship with mean climate, including its impact on the surface and atmospheric energy budgets.

To accomplish the above objectives, the PI and his team make use of the National Center for Atmospheric Research (NCAR) Community Atmosphere Model (CAM3) and a revised Zhang-McFarlane convection parameterization scheme developed by the PI. They performed multi-year ensemble simulations of the North American monsoon using the CAM3 global climate model, examining the sensitivity of the monsoon simulation to the model resolution and convection parameterization. The simulated seasonal monsoon evolution and diurnal cycle are compared extensively with in situ field observations as well as satellite estimates.

Research Accomplishments

This is the last year of the funded project, and the main work is to wrap up the project. The National Center for Atmospheric Research (NCAR) Community Atmosphere Model, ver. 3 (CAM3) is used to participate in a multi-model comparison in the North American Monsoon simulation.



California Applications Program (CAP)

Daniel R. Cayan (SIO)

NOAA Technical Contact: Caitlin Simpson (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The California Applications Program (CAP) and the California Climate Change Center (CCCC) aim to develop and provide better climate information and forecasts for decision makers in California and the surrounding region. Applications addressed include problems involving water resources, wildfire, and human health. Time scales of interest range from seasonal to secular changes associated with natural and anthropogenic influences. By working directly with users and practitioners, CAP and CCCC are working to evaluate climate information needs and utility from the user perspective.

Research Accomplishments

This year and last, CAP begins instead to leverage two new USGS ground-water model-upgrade projects to continue the exploration and integration of climate data, climate forecasts, and ground-water models. These upgrade projects have the advantage that very substantial additional funding resources for model construction and upgrades have been obtained from sources other than CAP; in association, their results are eagerly awaited and participated in by local and State agencies (which helps to ensure continuing local interest and buy-in). In part, as a result of these collaborations, the California Department of Water Resources has declared that they will use the USGS regional flow model for assessments of water resources in the Central Valley, California.

We have begun building climate change projections and linking them to the newly developed Central Valley Hydrologic Model (CVHM) to assess the affects on surface water, ground-water and agricultural use of water subject to projections of Global Climate Change. Because these GCM simulations and a downscaled estimate of historical precipitation and temperature overlap the original period of historical model calibration 1961 – 2003), an assessment of skill will be made by comparing these estimates against the original calibrated model results. These simulations are being driven by precipitation and minimum/maximum temperatures from the GCMs directly and indirectly. The precipitation data is being processed through a Precipitation runoff model to provide streamflow and reservoir input through our collaboration with Noah Knowles and his involvement with



the Cascade project. The reservoir input is being processed through the CADWR water allocation model, CALSIM-II, to generate reservoir releases on the major rivers in the Sacramento and San Joaquin Valley portions of the Central Valley. The software needed to translate the downscaled data into model input has been completed.

CAP funds to the Hydrologic Research Center were used to assess the benefit of three dimensional NCEP CFS data for the integrated management system INFORM that is now operational for the major Northern California reservoirs: Folsom, Englebright, Oroville, Shasta and Trinity reservoirs (Final Report of the first phase of INFORM at California Energy Commission web site: http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2006-109.html). The work was performed in close collaboration with the National Centers for Environmental Prediction (NCEP), who produced prototype datasets for HRC's use on this project for two significant historical flow periods.

As part of the CALFED State of Science Editorial Board and CALFED Climate Advisor, Dettinger provided climate-science and water-resource management leadership in planning and assessment activities of the CALFED Bay-Delta Restoration Program's Science Elements. Another two elements of the CALFED climate-science "white paper" have been published: A review of paleoclimate needs for CALFED's objectives (Malamud-Roam et al 2006) and a review of the history (and climatic underpinnings) of California levee breaks (Florsheim and Dettinger, 2007). Cayan and Dettinger received the 2007 Climate-Science Service Awards from the Department of Water Resources.

Alexander Gershunov has forged new collaborations with Helene Margolis (Cal. Dept. of Public Health and UC Davis Medical School) and Hilary Godwin (UCLA School of Public Health); they are beginning to investigate effects of recent heat wave activity on human morbidity and mortality in California (with Helene Margolis) and LA County (with Hilary Goodwin). Helene Margolis is holding a meeting on heat-related illness/mortality prevention May 13th.

Gershunov with Kanamaru and Kanamitsu of Scripps have studied the probability structure of extreme precipitation events over California's complex topography using fifty-six years of daily station observations (> 400 stations) and a fine scale (10km) downscaling of the NCEP/NCAR reanalysis (CaRD-10) over California. This work focuses on stochastic analysis initially applied over North America (Panorska et al. 2007), where it was shown that the fundamental nature of extreme precipitation probability structure (exponential or heavy probability tails) depends on the diversity of precipitation producing mechanisms, including topographic diversity.

Several of the studies from the Scenarios Assessment have been tailored for journal publication and have just been published as a special issue of Climatic Change; e.g. Cayan et al. 2008. Work has begun to conduct the next California assessment, to be completed by the end of 2008. This effort will consider six climate models, each providing two greenhouse gas emissions scenarios along with a historical (20th Century) simulation to study impacts of climate change in the California region.

Anthony Westerling's 2006 paper on climate, wildfire, forecasts and economic evaluation in Science is one of the most cited papers in the geosciences in the past two years. Three book chapters targeted to a general (educated) audience reviewing climate change impacts on wildfire in English, Spanish and Galega (Galician dialect similar to Portuguese) were solicited in 2007. The Galega edition is published, the Spanish version is accepted and the English version is in press. This work was recently featured in the Fire Science Digest of the interagency Joint Fire Sciences research program and Sunset Magazine, and will be featured in Feb 2008 as a 'fast breaking paper' by Thomson Scientific.

CEFA co-organized with the Climate Assessment for the Southwest (CLIMAS) RISA and the National Interagency Coordination Center (NICC) the National Seasonal Assessment Workshops for Eastern and Southern States (January 2007) and Western States and Alaska (April 2007). The purpose of these workshops is to bring together fire managers, fire meteorologists, fire and fuel specialists, and climatologists to develop an assessment of recent past and current conditions, and prepare an outlook for the upcoming season that combines climate, fuels and fire management information. The western workshop also included representatives from Canada and Mexico to prepare a North American seasonal outlook. Workshop reports are available online at CLIMAS. The two workshops will continue in 2008.



Members of CAP participated in the San Francisco Water Utilities Climate Change Summit held January 30-31 in San Francisco. This meeting clearly showed that the majority of water managers are now taking climate change seriously within the state of California. The summit highlighted the little-appreciated effects of just a few inches of sea level rise on the operations of storm sewer systems in the Bay Area and especially San Francisco itself.

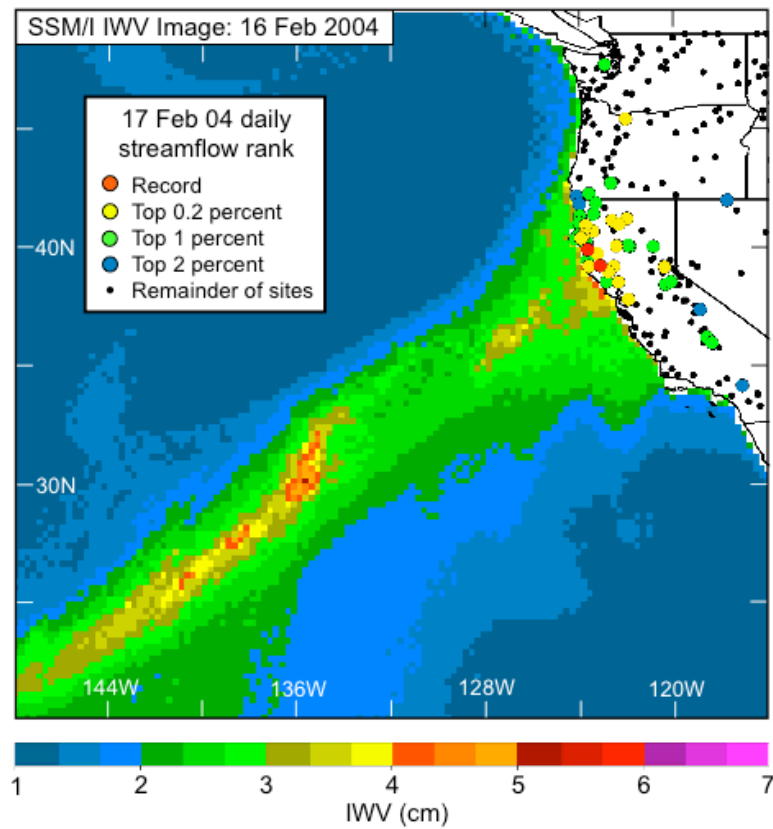


Fig. 1 Atmospheric rivers (ARs, transient low-level jets of water vapor-laden air that conduct much of the midaltitude transports of vapor) have been shown to be the most frequent cause of river floods in California. Here a particular AR is illustrated in an SSM/I satellite image of precipitable water (cm of water; color bar at bottom) for 16 Feb 2004, along with rankings of daily streamflows on 17 Feb 2004 at USGS gauges that have recorded data for >30 years. High-flows resulted in rivers along the Northern California coast and in numerous basins of the western Sierra Nevada. An evaluation of past floods and ARs has shown that all 7 of the declared floods on the Russian River of coastal California in the past 10 years were associated with landfalling ARs, as have all 9 of the largest winter floods on the Carson River in the eastern Sierra Nevada in the past 50 years. CAP is working with the California Department of Water Resources and with the NOAA Earth Systems Research Laboratory to develop and implement a monitoring and modeling program to address, track and better predict these AR events and their flood consequences

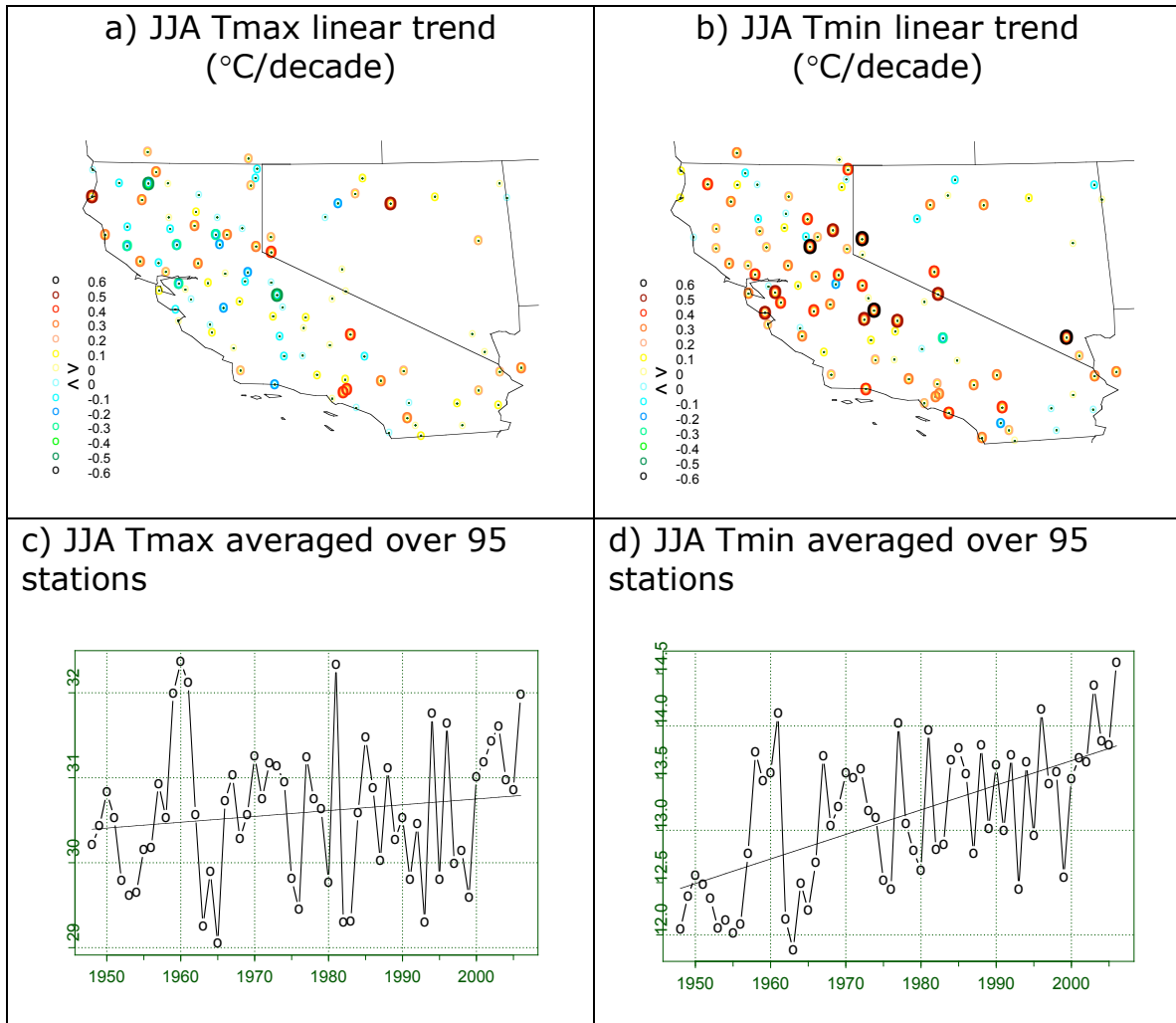


Fig. 2 Linear trend in JJA Tmax (a) and Tmin (b) by station. Dots mark the 95 stations analyzed, colors correspond to linear trends per decade. Bottom panels show trends averaged over the 95 chosen stations and fitted regression line (c,d). Region-averaged Tmax/Tmin trend is 0.07/0.24°C per decade (0.4/1.4°C over the 59-year record). Daytime (Tmax) and nighttime (Tmin) summertime average trends go hand-in-hand with heat wave occurrences expressed in day and nighttime temperature extremes, which these average trends partially reflect and partially determine



Preparation and Analysis of an Extensive Historic Dataset of Ocean CO₂ Partial Pressure and Related Measurements

Ralph Keeling (SIO)

NOAA Technical Contact: Lisa Dilling (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

Our ultimate goal is to produce a data set of the partial pressure of CO₂ gas (pCO₂) in the ambient air and the surface ocean from measurements made on five expeditions in all of the major oceans during the period between October 1957 and September 1967 (Table 1). These measurements were made on ships operated by Scripps Institution of Oceanography (SIO) by personnel of the Carbon Dioxide Research Group (CDRG) under the direction of Charles D. Keeling. We plan to make final computations and produce a fully calibrated data set of the true pCO₂ in the air and surface ocean as hourly averages and as a function of geographic location.

Scale differences on the CO₂ analyzer between reference gas traces and those of ambient and equilibrated air, on an hourly frequency, will be entered into a database. Calibration data of the sensitivity of the instrument from scale differences of CO₂ reference gases will also be entered as well as shipboard auxiliary data, consisting of ambient and equilibrator temperatures and barometric pressures along with geographic locations and salinities where available. Scale differences will be converted to CO₂ index values using the gas calibration data and then to mole fractions and pCO₂'s in the water and the atmosphere using the manometric calibrations made at SIO over the years and auxiliary data. Ultimately a database of final results will be constructed and deposited with the National Oceanographic Data Center (NODC), operated by NOAA, and with the Carbon Dioxide Information and Analysis Center (CDIAC) of the U. S. Dept. of Energy.

Research Accomplishments

The database constructed by the late Lee Waterman in 1996 for the first three expeditions, DOWNWIND, MONSOON, and LUSIAD, has been placed on the Scripps CO₂ Program's web site. These data sets include hourly averaged data along the ship tracks in the form of mole fractions of CO₂ in dry air for equilibrated surface ocean water and for the atmosphere above. The accompanying draft technical report by L. Waterman et al., entitled "Quasi-simultaneous CO₂ Measurements in the Atmosphere and Surface Ocean Waters from Scripps Institution of Oceanography DOWNWIND, MONSOON, and LUSIAD Expeditions 1957-1963," has also been placed on the web site in PDF format. The data sets should be regarded as preliminary, pending more detailed review and subsequent revision. In addition to the mole fractions already calculated, the revised data sets likely will include the calculated difference in fugacity of CO₂ between the surface ocean water and the atmosphere.

The remaining two data sets for NOVA and EASTROPAC expeditions in 1967 have been located in the archives at Scripps, but not yet in electronic form. It is likely that the primary data will have to be manually entered into digital format. Considerable workup of the data from these expeditions had been made at SIO in the early 1980s.

Remaining tasks to produce the final data set include detailed review of the calculation procedures in the existing data sets for DOWNWIND, MONSOON and LUSIAD expeditions. Calculation of the difference in fugacity of CO₂ between the water and the air above will be included. Problems in the calibration of the data due to the leaking analyzer detectors will be addressed. Direct experimental data quantifying these effects are absent, but indirect data in the form of atmospheric air samples collected in flasks during the expeditions and analyzed at SIO may allow corrections to be estimated. It is likely that such corrections will not be large relative to the precision of the equilibrated CO₂ data. As for the remaining data sets for NOVA and EASTROPAC expeditions, the electronic data sets will be created and calculations carried out as done for the earlier expeditions.



Expedition	Vessel	Latitude Zone	Period of Sampling
Atlantic Ocean			
3. Lusiad	<i>Argo</i>	20°N-40°S	Jun. 1963 to Jul. 1963
Pacific Ocean			
1. Downwind	<i>Horizon</i>	40°N-50°S	Oct. 1957 to Dec. 1957
2. Monsoon	<i>Argo</i>	40°N-70°S	Feb. 1961 to Apr. 1961
3. Lusiad	<i>Argo</i>	20°N-40°N	May 1962 to Jun. 1962
3. Lusiad	<i>Argo</i>	0° -40°N	Aug. 1963
4. Eastropac	<i>Argo</i>	40°N-20°S	Jan. 1967 to Mar. 1967
5. Nova	<i>Argo</i>	40°N-40°S	Apr. 1967 to Sep. 1967
Indian Ocean			
3. Lusiad	<i>Argo</i>	10°N-60°S	Jul. 1962 to May 1963

Table 1 List of SIO expeditions between 1957 and 1967 with concurrent oceanic and atmospheric pCO₂ data



CO₂/CLIVAR Repeat Hydrography Program CO₂ Synthesis Science Team

Andrew G. Dickson (SIO)

NOAA Technical Contact: Joel Levy (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The NOAA/NSF Repeat Hydrography CO₂/tracer Program is a component of the Carbon Cycle Science Program (CCSP) and is a collaborative effort between NOAA and NSF to conduct a global decadal time-scale sampling of ocean transports and inventories of climatically significant parameters. It provides a core set of carbon and tracer measurements and anticipates that additional carbon/CLIVAR measurements will be added to the cruises on an "as required" basis. The sequence and timing for the sections takes into consideration the CCSP objectives, and considers the timing of national and international programs. The new data from this program needs to be synthesized into a globally consistent data set (e.g. corrected for analytical errors and systematic biases) and combined with similar data sets from our international partners working on this same problem.

The CO₂ Science Team has been formed to meet these goals. It meets at least once a year, and corresponds in between meetings working to ensure that the surveys are carried out in an efficient manner, and that the data obtained are consistent and correct.



Research Accomplishments

The Science Team funded by this grant (Project Director, Dr. R. Feely, NOAA/PMEL) did not meet in this time period.

However, I have continued to work on ensuring data from my SIO group is in the appropriate form for public release. The following cruise data have been finalized and are at CDIAC. Data for A20, P02, and P16S. We will shortly finalize plans for the remaining cruises: I8S/I9S and I6S.

An additional task was completed as part of this work was, in collaboration with Dr. C. Sabine (NOAA/PMEL) and Dr. Christian (University of Victoria, Canada) to revise the 1994 DOE Handbook of measurement techniques for oceanic CO₂ measurements. This was published in late 2007.

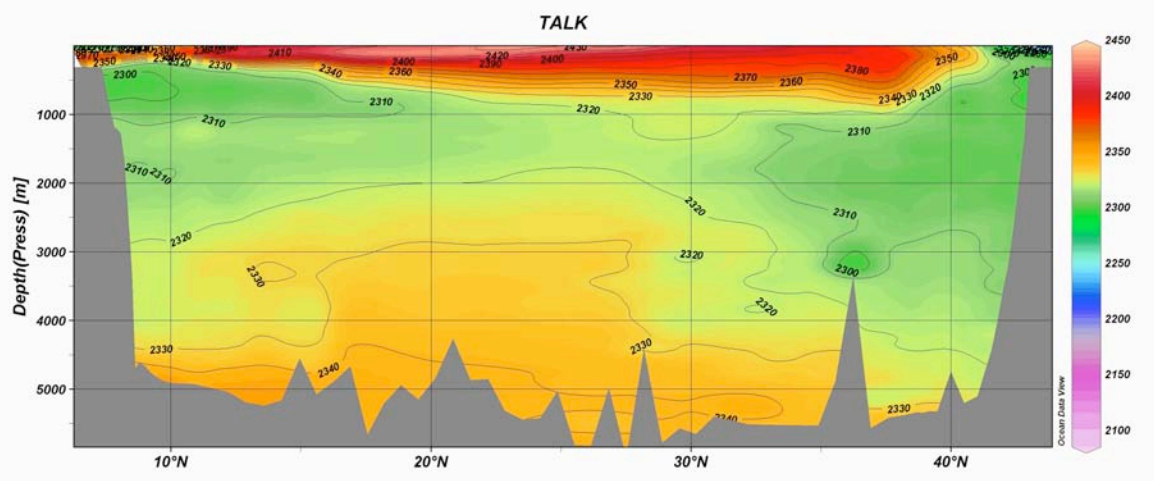


Fig. 1 Contour plot of data for total alkalinity measured on the A20 cruise in the Atlantic Ocean. Measurements were made at the locations indicated by dots



Oceanic Measurements of Total Alkalinity

Andrew G. Dickson (SIO)

NOAA Technical Contact: Kathy Tedesco (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

High quality surface alkalinity data is an integral part of current oceanic carbon cycle science. In particular, it is an essential part of the current method used for the estimation of anthropogenic CO₂ in the ocean. Here, it is used in two contexts: it is used as a reference level for inferring changes in alkalinity since a water parcel left the surface, it is also used as the basis for estimating the preindustrial total CO₂ content of a parcel of ocean water by calculating this value from the surface alkalinity and a p(CO₂) value of 280 μ atm. The uncertainty of our present data set for alkalinity compromises the sensitivity of these calculations.

This project has two key thrusts:

1. Improvement of the measurement technique for alkalinity by developing a spectrophotometric-based end-point detection technique for both at sea, and for shore-based measurements.



2. The accumulation of a high-quality global data set for the distribution of total alkalinity in the surface waters of the global oceans. This is being achieved out by shore-based laboratory measurements of alkalinity on samples collected on a variety of international oceanographic cruises.

Research Accomplishments

1. A rigorous assessment of the sources of uncertainty involved in the determination of alkalinity using an open-cell titration was presented at the BERM-11 meeting, November 2007, and is now being written up for publication.
2. We have been testing an improved LabVIEW program for the laboratory titration of alkalinity that can be used both in the laboratory as well as at sea. This version is a little more automated, and has been converted to operate on a Windows laptop computer. Eventually, we plan to modify the code to use alternate temperature sensors so as to make the whole system more compact.
3. A student (Adam Radich) has been working on the development of a Matlab-based code to process data from a spectrophotometric alkalinity titration. This holds promise, but we – as yet – have made limited progress beyond theoretical evaluations of the concept. The key benefit expected is that the titrations will be less dependent on “perfect” glass electrodes. The analysis of the uncertainty in our potentiometric titrations (research accomplishment 1) has highlighted the potentially significant contribution of non-Nernstian electrode behavior; our model titrations suggest that the use of a well-calibrated pH indicator dye will improve this situation.
4. Completed the analysis of further alkalinity samples in the laboratory. These include samples collected from the equatorial Pacific on the NOAA ship *R/V Ka'imimoana*, as well as a variety of samples obtained from other parts of the world including the CalCOFI region off Southern California. We are now working to ensure this data is archived appropriately.

parameter x_i	$\frac{u(A_T, x_i)}{\mu\text{mol kg}^{-1}}$	$\frac{u(A_T, x_i)}{\mu\text{mol kg}^{-1}}$
acid concentration (C_a)		0.49
sample size (m_0)	0.49	0.49
temperature (T)	0.07	0.07
salinity (S)	0.00	0.00
Nernst factor	0.20	0.64
K_F		0.32
K_S		0.10
titrant mass (m)	0.49	0.49
E.M.F (E)	0.35	0.35
CO ₂ removal	0.20	0.30
	0.78	1.2
<p>pooled std. dev. 0.76 $\mu\text{mol kg}^{-1}$</p> <p>intermediate precision (within batch)</p> <p>overall analytical uncertainty</p>		

Fig. 1 Table of uncertainty contributions to overall analytical uncertainty of an open-cell alkalinity titration. The column marked intermediate precision omits those error contributions that would not be expected to show up in the standard deviation observed within a batch. Note that this is almost equivalent to the pooled standard deviation for all alkalinity titrations on our reference materials, suggesting that the uncertainties have been appropriately estimated



Southern California Coastal Ocean Observing System (SCCOOS)

John Orcutt, Russ Davis and Eric Terrill (SIO)

NOAA Technical Contact: Geno Olmni (NOS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

Research Objectives and Specific Plans to Achieve Them

The Southern California Coastal Ocean Observing System (SCCOOS) is one of eleven regional ocean observing systems that contribute to the coastal component of the Integrated Ocean Observing System (IOOS). SCCOOS is an integrated, multidisciplinary coastal observatory that monitors and integrates ocean and climate observations in the Southern California Bight (SCB) to provide information and assist resource managers in addressing issues in coastal water quality, marine life resources, and coastal hazards. Ocean and coastal observations, data exchange and dissemination, modeling, research and education are designed to meet information needs of data users in the region. The system provides data to users of real-time observations and model-based forecasts using a flexible information distribution system.

SCCOOS is building an operational observation system whose components include HF radar surface current mapping, nearshore observations of water quality, subsurface observations (including gliders, AUVs, underway-CTD & moored observations), pier-based observations, satellite imagery, data base management in real time, and the implementation of a data assimilative ocean modeling operating in near real time. The work described represents the multi-disciplinary and collaborative efforts of the research teams that are contributing to the design and products of the SCCOOS infrastructure.

Research Accomplishments

HF Radar

- NOAA funding supports two long-range HF radar operated and evaluation by SCCOOS with delivery of generated data to NDBC. These systems complement the siting and installation of short-range HF radar by SCCOOS through the Coastal Ocean Currents Monitoring Program (COCMP) funded by the State of California. The SCCOOS network has benefited from the leveraging of a project that NOAA NDBC and NOS has with SIO, UCSB, and UCSC for a) developing the data management architecture for a national network of HF radar and b) developing and documenting a quality assurance/quality control algorithms and procedures.
- A simulation effort has continued this past year to examine the skill of HF radar to resolve currents of varying complexity. The work has indicated areas of research that would lead to improvement in the retrieval of currents using the technique. The simulations also revealed the importance of tracking the radio frequency SNR of the system for future quality assurance and quality control (QA/QC) algorithms. This will be examined in the future using pre-existing data sets. The results of the simulation activity were submitted to the Journal of Atmospheric and Oceanic Technology to communicate the results to a broader audience of HF radar users.
- Also over the past year, QA/QC procedures were evaluated by members of the research team for operational processing of radial current vectors and total surface current vectors. Various parameters computed from standard operational software (e.g. signal-to-noise ratio) were compared with statistical measures of velocity differences between HF radar-derived currents and currents measured by in situ current



meters. These parameters were also used in the evaluation of baseline velocity difference, a robust indicator of consistency in radial currents measured by different radar systems. Additionally, several distance-based weighting schemes were evaluated in the estimation of total vectors. Reports summarizing the results of these studies have been submitted to NOAA.

Autonomous Observations

- SCCOOS maintains two glider sections with NOAA funds that are coincident with CALCOFI lines 80 and 90. These lines are maintained near continuously to provide sections of temperature, salinity, velocity through an acoustic Doppler profiler, chlorophyll, and acoustic backscatter which can be used as a proxy for zooplankton.

Moorings

- Santa Monica Bay Multidisciplinary Mooring: The interdisciplinary SCCOOS UCLA mooring in Santa Monica Bay has been a part of SCCOOS since 2004. The current deployment period started in May 2007 and the recovery is planned for summer 2008. The mooring monitors meteorological parameters and atmospheric CO₂. At the sea surface, it measures temperature, salinity, chlorophyll fluorescence, light transmission, dissolved CO₂, and currents (4-100 m). The stratification of the upper 90 m is measured with 10 additional temperature and salinity sensors. The water depth is 400m. The mooring measurements are complemented by bi-weekly cruises to the mooring site with measurements of CTD profiles, DIC, alkalinity, nutrients (silicic acid, nitrate, nitrite, phosphate), chlorophyll-a, phytoplankton species (N. Gruber, R. Shipe, UCLA), and trace metals (until 2006, J. Adkins, CalTech). All mooring data, except pCO₂, is transmitted with a radio link to land in near-real time and is publicly available at www.smbayobservatory.org. The data is also recorded internally.

Nearshore Observations

- Along coast nowcasts and forecasts of wave height and alongshore currents driven by waves are provided by the Coastal Data Information Program (www.cdip.ucsd.edu)
- Four pier shore stations are maintained that consist of measurements of temperature, pressure, salinity, and chlorophyll.

Marine Life Resources

Harmful Algal Bloom (HAB) Monitoring Program

- Monitoring of HAB species has been conducted from the Oceanside and Scripps Pier in an effort to develop methodologies for a Bight-wide HAB monitoring effort. Analyses for the presence of toxins is conducted when toxin-producing species are identified.

Scripps Pier Chlorophyll Program

- The monitoring of chlorophyll, nitrates, and silicates are conducted 3x a week to develop appropriate methodologies for monitoring large-scale areas to examine the relationship between local biological productivity and nutrient inputs. Understanding these processes is key in understanding what forces algal blooms.

Modeling and Assimilation

- The modeling and assimilation teams supported by SCCOOS have recently deployed a quasi-operational ocean circulation model using the regional ocean modeling (ROMS) system. The system assimilates ocean information, including currents measured by HF Radar and subsurface ocean state variables measured by gliders. The model also assimilates available remotely sensed fields of temperature and altimetry.
- Statistical decomposition of the measured surface current fields has been conducted to develop statistical models of ocean response to the forcing variables.
- Covariance analysis of surface current data has allowed an objective mapping technique for HF radar derived surface current velocity fields to be developed, in addition to the near-realtime mapping of streamlines and vorticity fields to aid in the identification of coastal eddies. These approaches are being used to provide an optimal surface current map product.



- A high resolution ROMS model run was conducted for fall of 2006 that included the influence of waves on sediment transport in the Huntington Beach region.

Data Management and Information Technology

- Through continued collaboration with other program participants, HFR data is currently being shared for the generation of data products benefiting the public. SCCOOS continues in its implementation of the COCOMP HF radar data exchange for all of California and has made significant advances in building HF radar data transport for the region. SCCOOS programmers also continued development on HF radar metadata and implementation of a network Common Data Format (netCDF) for data dissemination of statewide HF radar surface current maps.
- A total of 10 new HFR sites were added to the near-real time data acquisition and processing system for a total of 45 sites within California. An additional data acquisition computer (Portal) was deployed at University of California, Santa Cruz (UCSC) (07/25/2007). There are now five operational portals deployed in California and one that is ready for integration at the University of Southern California. The previous deployed portals are operational at University of California at Santa Barbara (UCSB) (2006/01/30), San Francisco State University (SFSU) (2006/04/11), California Polytechnic State University (Cal Poly) (2006/11/15), and Scripps Institution of Oceanography (SIO). The UCSC High Frequency Radar Network (HFRNet) Portal was brought on-line to serve data from UCSC/NPS HFR sites on December 5, 2007. The installment of this Portal lightens the load on the SFSU Portal providing a larger buffer for each system. This larger buffer effectively enables the system to tolerate longer network outages. The SFSU portal remains in operation and continues to serve data from SFSU and BML HFR sites. Future HFRNet development includes deployment of a data repository computer (node) at UCSC and enabling access to total vector data.
- SIO SCCOOS programmers have developed detailed system diagnostic utilities from the available metadata allowing for a quick look at data transfer latencies, system health, data reliability, and error estimates. SCCOOS staff have drafted a working document: Deployment & Setup of a High-Frequency Radar for Ocean Surface Current Mapping: Best Practices.
- The SCCOOS data management team focused considerable time on configuring an interactive Federal Geographic Data Committee (FGDC) compliant metadata engine. Programming this system required a significant amount of research into various metadata standards and cataloging software. Many of the available tools were either not fully compliant or relied on vendor supported databases. Although the SCCOOS programmers used existing community accepted standards, new code was needed for the backend system. Future work will include populating the database for a full FGDC compliant metadata catalog of SCCOOS data. Programmers also began work on implementing the common application programming interface (api) for ease of access to existing metadata, as well as contributing to NOAA's IOOS Regional Observations Registry.
- Product development continues to advance as SCCOOS programmers were able to improve the data management administrative interface to databases by adding a summary page for collections of measurements displaying some statistics, a plot of surface data, and a small map. This interactive administrative interface allows for quick data looks and statistical summaries. Optimization of the data system for fast retrieval continues to require time and constant updating as the near real-time system grows.

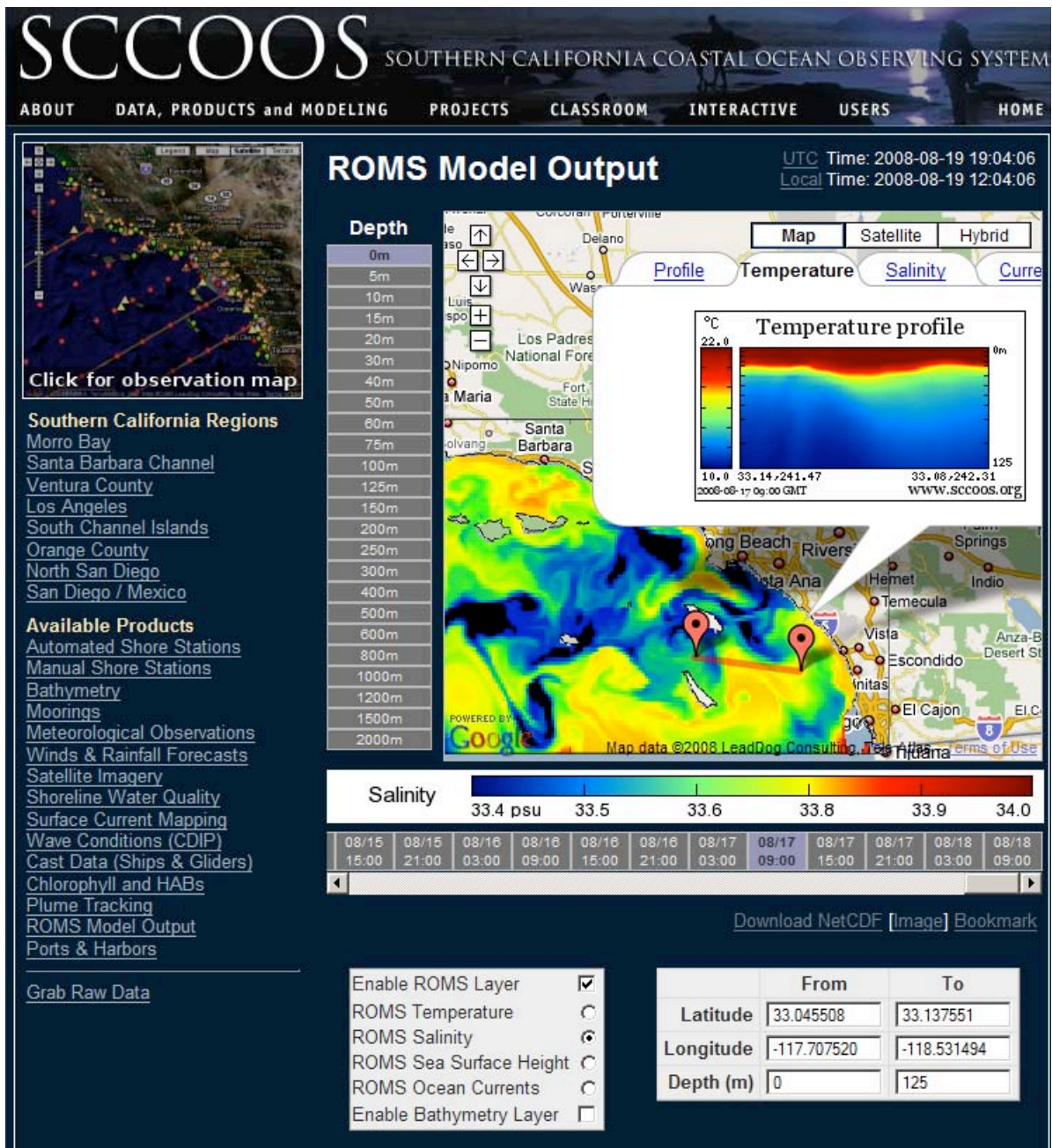


Fig. 1 Interactive graphical display of ROMS Model output allowing user multiple views of selected layer: depth, profile, and cross-section

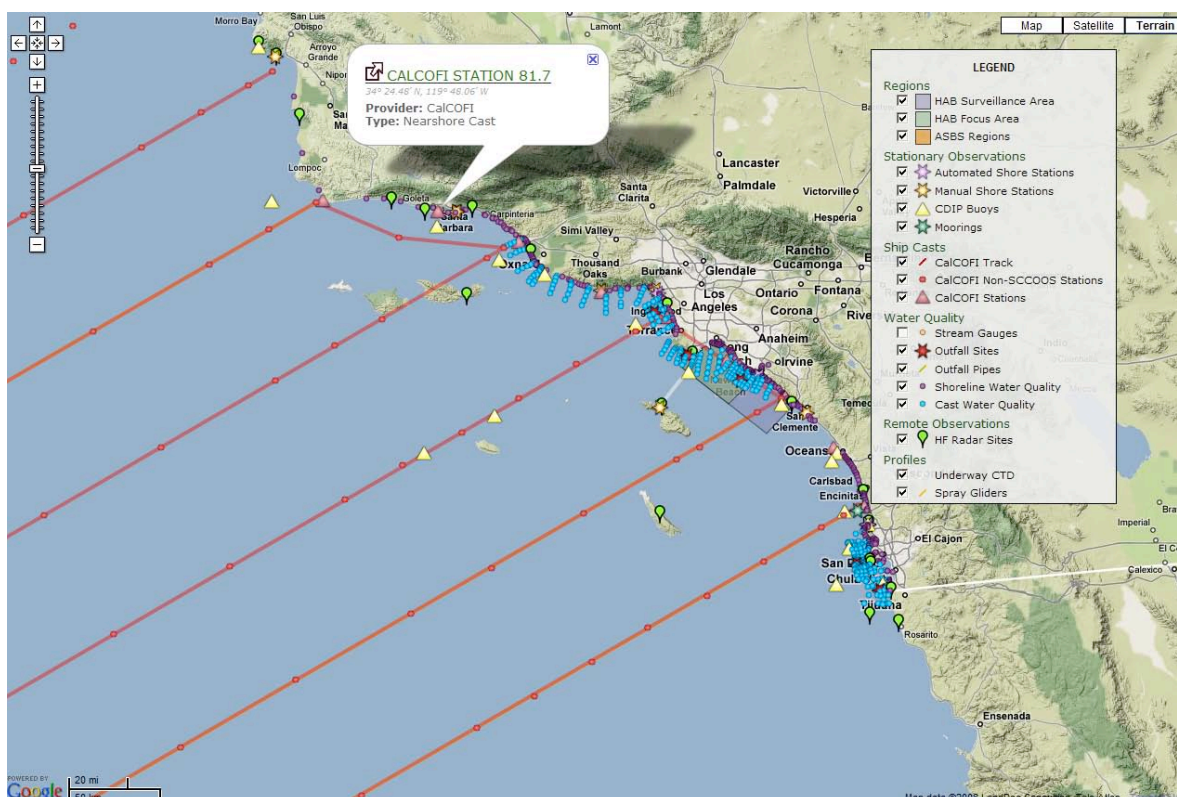


Fig. 2 Google maps display of SCCOOS observations



HF Radar National Data Management Development

Eric Terrill (SIO)

NOAA Technical Contact: Don Conlee (NWS/NDBC)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

NOAA Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

NOAA Goal 5: Provide Critical Support for NOAA's Mission

Research Objectives and Specific Plans to Achieve Them

Local, state, regional, and federal discussions directed towards the establishment of an Integrated Ocean Observing System (IOOS) continue to emphasize a desire for the installation, development, and operation of a network of surface current mapping systems for use by a broad range of end users. Central to the operational success of a large-scale network is a scalable data management, storage, access, and delivery system. The objectives for this project are to continue the research, development, and implementation of a prototype data management system for ocean surface current information derived from HF radar.

The architecture of the HF-Radar Network lends itself well to a distributed real-time network and serves as a model for networking sensors on a national level. This joint University-NOAA partnership is focused on defining



and meeting the expressed needs for an IT architecture supporting a national network of surface current mapping data systems. Research and implementation efforts met expectations during this reporting period. Programmers maintained and upgraded the regional aggregation systems (portals) and centralized data repositories (nodes), implemented level one quality control algorithms into the near real-time processing stream, initiated integration for WEllen Radar (WERA), and standardized the total vector file format. This project has also supported the research and analysis of the Multiple Signal Classification (MUSIC) algorithm for application to quality control of HFR-derived surface currents, as well as supported the Radiowave Operators Working Group (ROWG) workshop held at Scripps Institution of Oceanography.

Research Accomplishments

This past year, significant progress has been made to the HF Radar data collection and dissemination efforts. As background, the HF-Radar Network architecture is comprised of two hardware building blocks, portals and nodes with distinct roles. Portals serve as 'point of entry' machines by acquiring and serving radial data from any number of HF-Radar sites. Nodes serve as data concentrators by collecting radial data from any number of portals (or nodes). This design minimizes data requests through sometimes-unstable network connections to individual sites by serving data through portals while maintaining a high degree of network flexibility through selective data collection at nodes.

As the network of HF radar systems grows nationally, programmers update and incorporate new data streams into the mapping system. In addition to data from new CODAR systems, radial files produced from two WEllen Radar (WERA) systems operated by the University of Miami were integrated into the network. These systems provide coverage of the Gulf Stream off of the East coast of Florida. Network maintenance included an upgrade to Real-Time Vector (RTV) processing which made site selection network specific in order to avoid namespace collision (i.e. confusion from two sites with the same name from different networks) as well as upgrades to Antelope version 4.9 across the entire network. Directory structures on both portals and nodes were standardized as part of the network upgrades. Testing and development continued for software supporting an expanded database schema, Hfradar0.6. Antelope license expiration warnings were automated from a centralized location network wide. Total vector velocity data are now stored in NetCDF format that complies with Climate and Forecasting (CF) metadata standards. Development also continued for further streamlining and automating database management for improved scalability with establishment of both short term and long-term goals.

Members from CORDC participated in the San Diego National Preparedness for Response Exercise Program (NPREP) and provided near-real-time data support to the California Office of Spill Prevention and Response (CA-OSPR) and to NOAA HAZMAT. Programmers developed a shape file format for use by CA-OSPR in this exercise and plan to make it an operational product in the future. NOAA HAZMAT received NetCDF files for use in their modeling environment (GNOME).

A Radiowave Operators Working Group (ROWG) workshop conducted 10-13 September 2007 at Scripps Institution of Oceanography brought together representatives of the HF radar technical community from around the nation. The main goal of the workshop was to garner input from participants into the draft Standard Operating Practices ("Best Practices") document highlighting the many aspects of HF radar operation, including siting requirements, communications, supporting equipment, software settings, data management, and quality assurance/quality control. SCCOOS staff have drafted a working document: Deployment & Maintenance of a High-Frequency Radar for Ocean Surface Current Mapping: Best Practices.

CORDC staff visited CODAR Ocean Sensors to discuss inclusion of the DOA metric and width / sigma around the peaks of the MUSIC solutions in upcoming versions of the seasoned processing. This would enable improved QC analysis of the radial data and further the development of a QC metric.

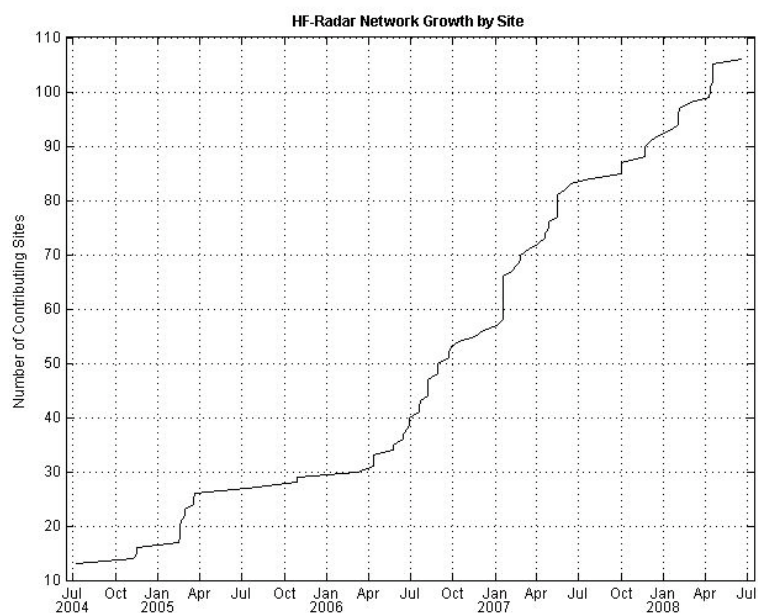


Fig. 1 Growth curve of the number of reporting HF radar sites whose data are managed by the data management system developed in this program. Over 1.5M data records presently reside within the system

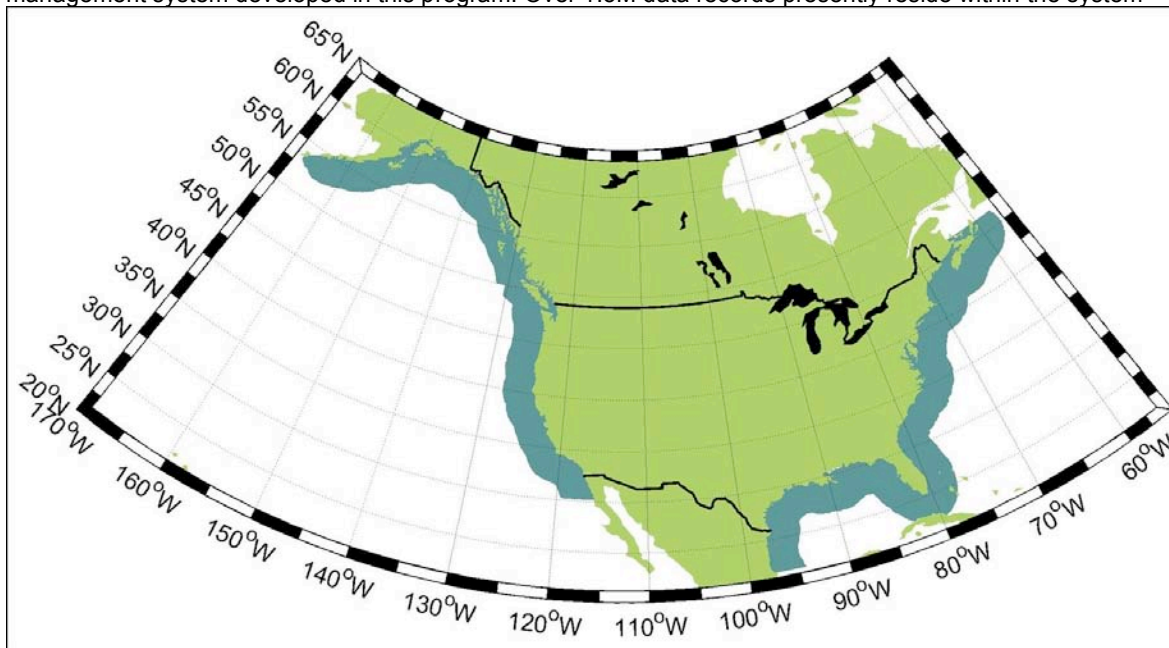


Fig. 2 This image depicts the existing grid coverage for mapping total vector surface currents which extends northwards to Alaska and includes Canada



THEME B: BIOLOGICAL SYSTEMS RESEARCH



California Cooperative Oceanic Fisheries Investigations (CalCOFI): Ocean Observations for Ecosystem-based Management

J. Anthony Koslow and Ralf Goericke (SIO)

NOAA Technical Contact: William Hogarth (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

CalCOFI's primary objective is to continue its 59-year time-series of comprehensive, high-quality physical, chemical and biological observations of the California Current ecosystem, with an emphasis on the living marine resources. CalCOFI serves as a cornerstone of the developing Pacific Coast Ocean Observing System (PaCOOS), which will provide the scientific underpinning for ecosystem-based management for the living marine resources from Canada to Baja California. The proposed work was to conduct four seasonal cruises: summer and fall, 2007 and winter and spring, 2008, using Scripps vessels for two of the cruises; to process the hydrographic, chlorophyll and primary productivity data, exercise quality control, and make the data available. CalCOFI also strives to increase the availability of data on the CalCOFI web site, improve the breadth and quality of CalCOFI's ocean observations, and foster and provide leverage for collaborative projects.

Collaboration with the NSF-funded California Current Ecosystem Long-Term Ecological Research (CCE-LTER) project continues successfully, as well as with a number of single-investigator projects. Projects were initiated, based on additional funding, to merge CalCOFI data sets at Scripps and the SWFSC/NMFS, improve CalCOFI data availability through the web, to survey mid- to higher trophic levels on CalCOFI cruises, and to develop time series of spiny lobster spawning stock using the historical CalCOFI samples. A major NSF/NOAA CAMEO project to study climate in relation to key California Current species along the west coast was proposed, leveraging off CalCOFI.

Research Accomplishments

We accomplished our objectives for the 2007-08 year: Four cruises were completed successfully. Basin-wide La Niña conditions were observed, which significantly affected mixed layer temperatures, nutricline depths and concentrations of nitrate in the mixed layer, but concentrations of chl a and zooplankton displacement volume showed little response. Unusually low oxygen concentrations (and likely low pH) were observed close to the coast in April 2008, which could significantly affect benthic life. We will follow up on this during the summer 2008 cruise, taking alkalinity and total inorganic carbon samples to calculate pH.

CalCOFI cruises continue to be used as a platform for ancillary research programs that greatly contribute to our understanding of the system. The California Current Ecosystem Long-Term-Ecological Research (CCE-LTER) group has participated on all four cruises, studying biogeochemical and lower trophic level processes. Marine mammal and seabird observations (independently funded) continue to be made on all cruises, providing with processes at the top of the food chain. For example, seabird abundance in our study area was characterized by anomalously high abundances of the common murre, which appears to be seeking richer feeding grounds in



our area after krill abundance collapsed off Central California during the past 2 years. With funding from the Moore foundation, a multi-frequency (18, 38, 70, 120, and 200 kHz) Simrad ES-60 acoustic system and pelagic trawl will be incorporated in Scripps' 2009 CalCOFI cruises. With state funding, phyllosoma are being sorted from the historical CalCOFI collections to develop time series of California spiny lobster spawning stock and recruitment as a means to assess relations with climate.

Processing of the data has been completed up to Cruise 0711; preliminary data are available for cruises 0801 and 0804. CTD data from this year are also available on-line and historical CTD data back to 1998 have been placed on the web as well. The SIO Ocean Informatics Group's DataZoo continues to be populated with CalCOFI data: queriable access is now available for the first time to CalCOFI's 31,500 hydrographic records. We are currently developing derived data products, such as interpolated fields of data, anomalies and geostrophic currents and transport that are to be made available to the public via the DataZoo. We have also begun an effort to mine historical data; currently we are collecting Chl a data from the 1960s and 70s that will be incorporated into the CalCOFI database. With state funding and in collaboration with NOAA's SWFSC, the ichthyoplankton and hydrographic data are now being merged.

Over the past year CalCOFI data provided the basis for several key discoveries related to climate-driven change in the California Current. Di Lorenzo and collaborators discovered a new mode of North Pacific climate variability, the North Pacific Gyre Oscillation (NPGO) index, which is well correlated with variability in salinity and nutrient availability in the California Current. Rykaczewski and Checkley showed that offshore wind-stress curl driven upwelling, rather than coastal upwelling, was significantly related to sardine production. Bograd and collaborators documented a substantial decline in oxygen concentration off southern California since 1984, with shoaling of the hypoxic zone on the shelf by up to 90 m. Barbeau and her students, using CalCOFI cruises as a research platform, have shown that iron limitation appears to significantly limit phytoplankton production in some areas of the California Current. Ohman and former post-doc Hsieh uncovered differential spatial patterns of mortality in copepods, with higher mortality inshore, probably due to higher predation levels in this more productive region. Ohman and former post-doc Lavaniegos showed that a long-term decline in pelagic tunicates, mostly salps, in southern and central California waters was responsible for the long-term decline in zooplankton displacement volume previously observed in the California Current. A proposal to the NSF/NOAA-funded CAMEO program was submitted with collaborators at Oregon State University, the Northwest and Southwest Fisheries Science Centers and other institutions to coordinate field studies of mid- to higher trophic level dynamics, along with modeling and retrospective studies of climate forcing of ecosystem and fishery processes in the northern and southern California Current. This is closely aligned with the goals of PaCOOS.

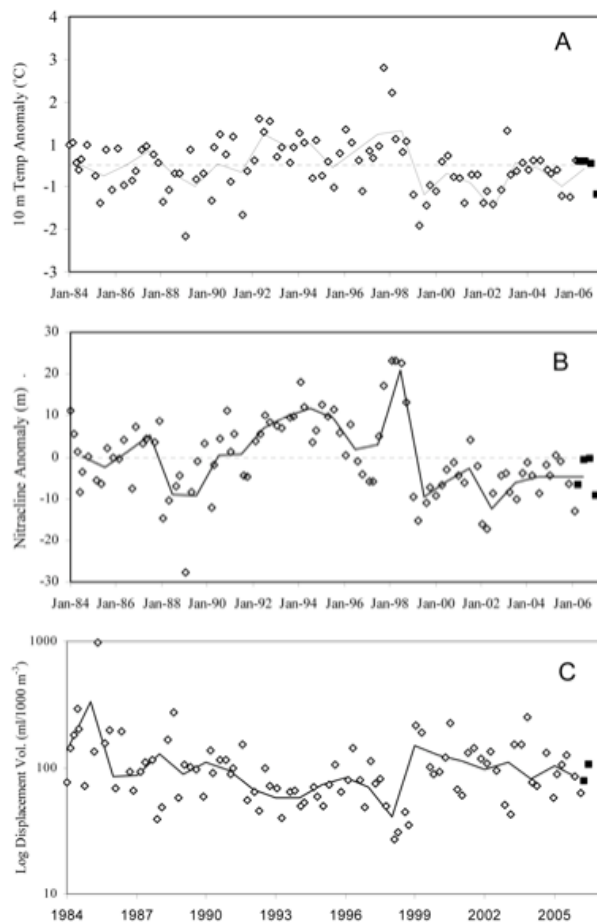


Fig. 1 Cruise averages for selected properties. These averages, i.e. the individual data points, encompass data from all 66 standard CalCOFI stations. Data from the last four cruises are plotted as solid symbols; data from previous cruises are plotted as open diamonds. The solid lines represent the annual averages and the dotted lines the long-term average, which in the case of anomalies is zero. a) Mixed layer temperature—The data show temperature significantly increasing over the 1984 to 1997 time period, undergo a step change associated with the 1998 regime shift and at that point increase again. The latter increase is not 'yet' significant. b) Nitracline depth—which is assumed to be the depth where nitrate reached values of $1 \mu\text{M}$. These data show that the period of shallow nitracline depths and presumed larger than average fluxes of nitrate into the euphotic zone continued over the last observation period. Similar to A, data are clearly delineated into two time periods, pre- and post-regime shift. The effect of the 97/99 ENSO event is very strong. c) CalCOFI cruise mean macrozooplankton displacement volumes plotted against time (note the log axis). Annual averages are connected by the solid line. Linear regression of values vs. time for the time periods 1984 to 1998 and 1999 to 2006 are significant ($p < 0.02$ and $p < 0.002$, respectively) with statistically identical regression coefficients (-0.035 ± 0.01 and -0.035 ± 0.01 respectively). These data suggest that biological variability—a proxy for zooplankton biomass in this case—is controlled by the availability of inorganic nutrients. The latter is likely affected by water temperature which is expected to rise due to global warming



An Investigation of Nonlinear Forecasting for Improved Stock Projections: Understanding Variability in Fish Populations

George Sugihara (SIO)

NOAA Technical Contact: R. Hewitt (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

1) The project objective of understanding sources of variability (both anthropogenic and environmental) will be addressed by using historical ichthyoplankton data for the CALCOFI domain. These are unique data that can be used to answer one of the classic questions in marine fishery management: whether fishing itself will increase or dampen the population variability of targeted fish species.



- 2) The project objective using nonlinear methods to improve prediction directly addresses the overall NOAA Fisheries mission. It is essential information for setting harvest targets of fished species in the CALCOFI domain.
- 3) The nonlinear methods used here directly address the mission of ecosystem-based management. This is done explicitly in the state space embedding procedure, in addressing the dimensionality question, and by identifying mutually co-predictive subsystems that may yield models with higher predictive skill. In the latter case we are determining the boundaries of the ecosystem view that is required for prediction (how complex does the best model need to be?).
- 4) Demonstrating the applicability of the forecasting technology and refining the methods to apply specifically to data of this kind (as must certainly be done) is of general utility to its future applications to other fisheries.

Specific questions and problems we address are as follows:

- 1) How predictable are fish larvae data in each ecological domain (taken as a composite over all species in an ecological region as defined by the expert systems habitat classification)?
- 2) Are exploited species inherently less variable than unexploited species? Are exploited species inherently less predictable than unexploited ones? Are there any systematic differences here? Can fishing affect dynamic stability? Is there a generic theoretical result? What empirical evidence is there for any effects of fishing predicted by models?
- 3) Is there much cross-predictability between regions? For example, does the model built for oceanic species, also capture the composite dynamics of the coastal species? If this is true it suggests that the environmental signal in spatially averaged coastal data produces an integrated average of the climatic changes that may also be occurring in the open ocean. This is important for next generation modeling efforts that may incorporate physical forcing variables.
- 4) What is the effective dimensionality of each of these problems? That is, how many variables are required to model the problem, in order to obtain a given level of predictability?
- 5) How does generation time affect scales of predictability?
- 6) Can cross-predictability between species be used to discern dynamically coupled subsystems? Such subsystems would represent natural communities, or functional assemblages. This can be determined by a hierarchical search that produces a matrix of mutual predictability between species and species groups. If so, can one build better forecast models by focusing on each of these more tightly connected ecological subsystems?

Research Accomplishments

We have obtained the following results:

- 1) Found fishing increases boom and bust variability of exploited populations. This is a classical question in fisheries science that we were able to answer generally and empirically for the first time. (Mentioned by VAdm Lautenbacher at the National Academies of Sciences November 2006). The implication of this work is that the destabilization of the population is a consequence of common fisheries practices that target the larger older individuals. Thus it is significant to restore age-structure in rebuilding depleted stocks.
- 2) Confirmed that fishing results in a truncated age and size structure for the population, and further related this to destabilization of exploited populations.
- 3) Found nonlinear forecast methods are effective for fisheries. These methods work best when the time series composite is constrained by habitat type or region.
- 4) Found physical data for CCE are best described as linear stochastic (auto-correlated noise). They are high dimensional and effectively stochastic.
- 5) Found low dimensional nonlinearity in the population dynamics of both exploited and unexploited populations. Dimensionality is a fundamental constraint on the complexity of a model required to achieve a given level of predictability.

Our results to date suggest that:

- 1) Time series forecasting methods should be deployed at very least as a supplement to existing stock assessment practices. They are shown to have significant forecast skill.
- 2) Fishery management policy and practices/technologies need to be developed to preserve age-size-structure of exploited populations. "Stop picking on the big guys" as the tabloids say.



Coherence of Euphausiid Variability in Southern and Central California Waters

Mark D. Ohman (SIO) and Baldo Marinovic (UC Santa Cruz)

NOAA Technical Contact: Jonathan Phinney (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

The objectives of this research project are to (1) enumerate some existing plankton samples that will permit us to fill in gaps in euphausiid time series and (2) to design a digital database that will eventually permit retrieval of the euphausiid data from two regions of the California Current System (Southern California and Central California) from a common web access portal.

In the 10 months of funding we have made substantive progress toward both of these goals. This represents a coordinated research activity of two nodes (SCCOOS and CenCOOS) within the developing PaCOOS network.

Research Accomplishments

Some current and archived plankton samples from CalCOFI and from line 67 off Monterey were analyzed microscopically to determine the dominant species and stage structure of euphausiid populations in the Central California region. These analyses focused on juvenile and adult developmental stages.

In addition, entry and QC of 192,000 records of 39 species of euphausiids was completed. These data originated from approximately 200 oceanographic cruises in the California Current System from 1949 to 2007, representing part of the career's work of Dr. Edward Brinton of the Scripps Institution of Oceanography, with the taxonomic assistance of Ms. Annie Townsend of the SIO Pelagic Invertebrates Collection. This time series continues under the guidance of Dr. Mark Ohman. Samples derive almost entirely from CalCOFI cruises in the region. This digitizing effort was begun before the present grant, but was completed with its support and has culminated in the Brinton-Townsend Euphausiid Database (BTEDB), developed by M.D. Ohman. In addition, all of the appropriate euphausiid enumerations from Dr. Baldo Marinovic's research in the Central California region were incorporated into a separate database, the Marinovic Euphausiid Database (MEDB), developed by B. Marinovic. Following construction of the two independent databases, a common web portal was designed to permit a single-entry point search to both databases. This is the Comprehensive Euphausiid Query Interface (CEQul), which represents a prototype for the type of shared, distributed databases that are anticipated under PaCOOS.

All of the above data were imported into MySQL and schema designed to permit queries to these data and to accommodate integration of the CalCOFI data with those from co-PI Marinovic's research. A web portal was created to permit online access to the enumeration data. The associated GUI-based search engine permits queries based on source of data, year, season, time of day, geographic location, species, phase or developmental stage, sex, and size. The results from the query can be displayed in tabular form or as figures. Data can be reported as individual measurements or statistical averages (mean \pm 95% C.L.), for counts standardized per unit sea surface area or per unit volume, on a linear or logarithmic scale.

In addition, although not part of our original proposal, we completed construction of a searchable gallery of unpublished euphausiid distributional maps from Dr. Ed Brinton's research, which can now be browsed and displayed, together with relevant physical data (10 m temperature, dynamic height anomalies). These maps originate from a series of cruises from 1969, the decade of the 1970s, and subsequent El Niño-associated intervals.

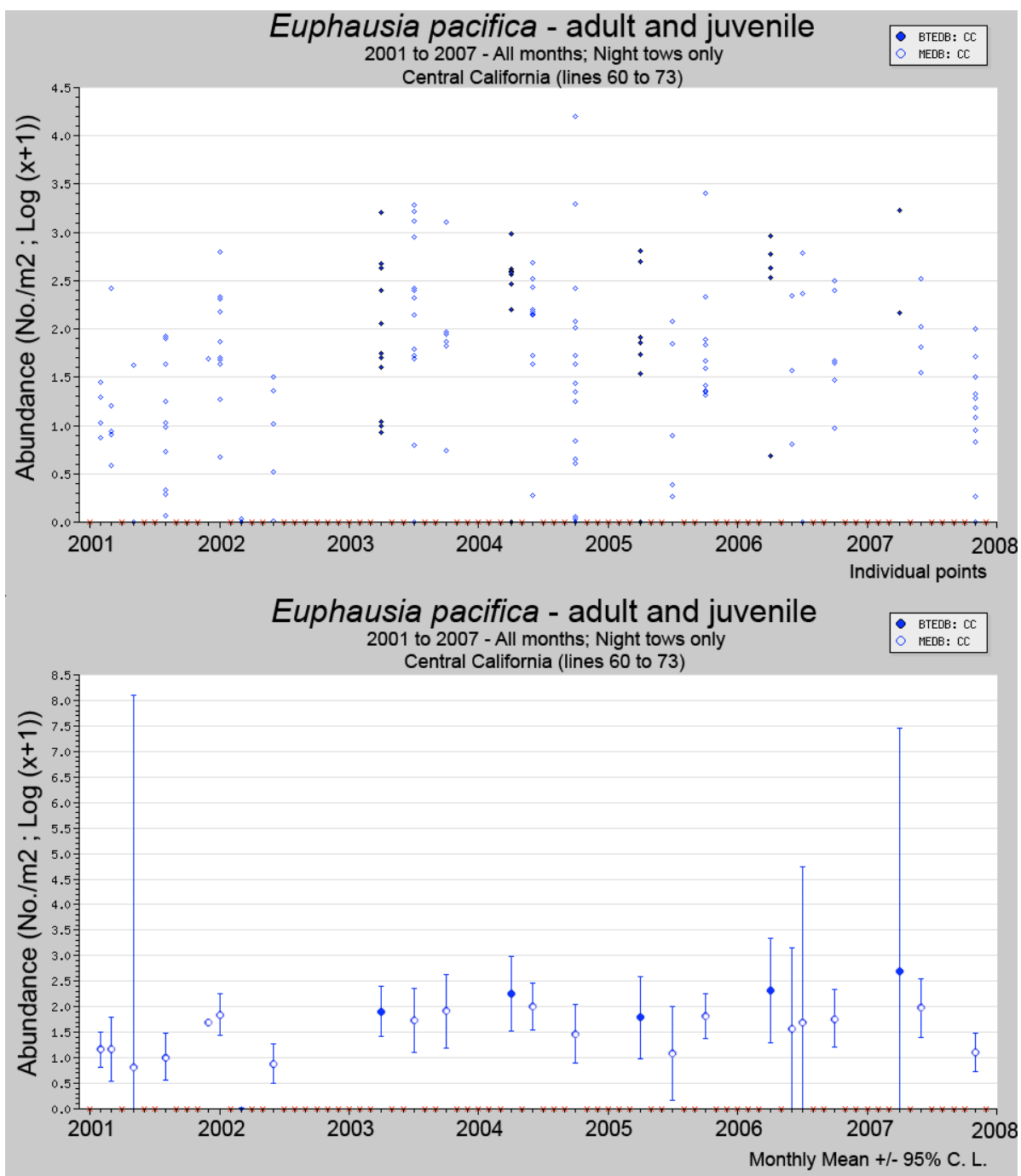


Fig. 1 Search screen for CEQuI (the Comprehensive Euphausiid Query Interface), which conducts distributed searches from two newly constructed digital databases of California Current euphausiid population data. Developed at the Pelagic Invertebrates Collection, Scripps Institution of Oceanography

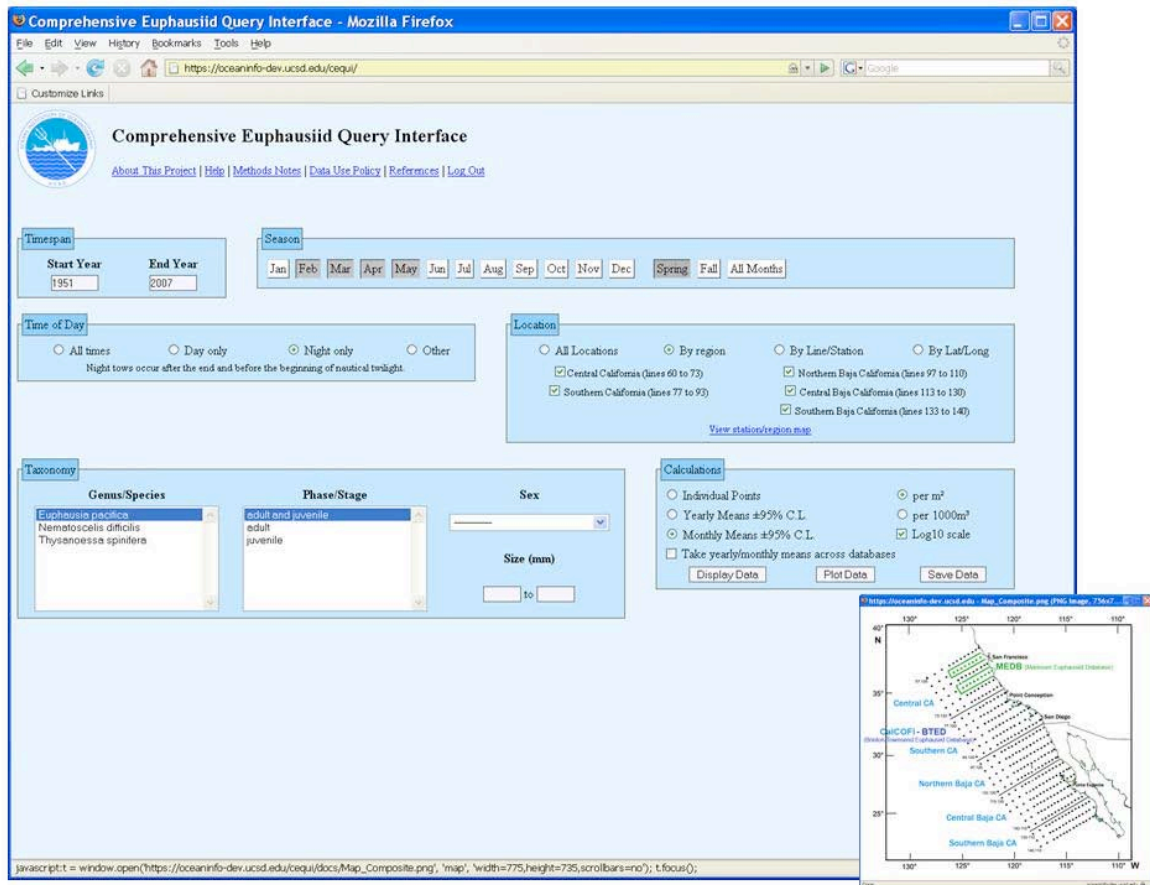


Fig. 2 Example of graphical results from queries from CEQul (the Comprehensive Euphausiid Query Interface). The left time series indicates individual data points, the right time series indicates monthly means \pm 95% C.L., for *Euphausia pacifica* adults + juveniles in Central California, from 2001-2007



The Center for Stock Assessment Research (CSTAR)

Marc Mangel (UC Santa Cruz)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The objective of CSTAR is undergraduate, graduate and post-graduate training in the basic science associated with the problems of assessing the numerical abundance, spatial distribution, size distribution and reproductive status of commercially important fish species. A broad and deep understanding of population processes is critical to the development and management of sustainable fisheries.

Finding means to conserve fish populations and to achieve sustainable fisheries requires understanding the effects of fishing on behavior, life history and population biology of exploited fishes. At CSTAR, work focuses on



using mathematical, statistical and computer models to solve important environmental and ecological problems. The work is grounded in data, and also seeks to expand the base of basic knowledge that supports rigorous application of science to real-world problems. Furthermore, research on marine fisheries conducted at CSTAR allows testing theoretical predictions via natural and human experiments on a scale that is appropriate for understanding the dynamics of ecosystems. Such large-scale experiments are rarely available to the scientific community.

The CSTAR grant provides level of core support which is then leveraged by teaching assistantships and graduate research assistantships from other grants or contracts. This enables us to create a relatively large and interactively group of quantitative scientists working on a wide range of problems in fishery management.

Research Accomplishments

In 2007-08, Dr. Yasmin Lucero (CSTAR Ph.D. June 2007) worked for CSTAR for two months and then moved to the Northwest Fisheries Science Center as a NRC Post-doctoral Fellow; Mr. Anand Patil defended his Ph.D. thesis (on Bayesian nonparametric methods in ecology) and then worked for MRAG Americas for 6 months before moving to the University of Oxford as a post-doctoral scholar; Ms. Erin Middleton (undergraduate major in Environmental Studies with a minor in Mathematics) conducted an independent study with Prof Marc Mangel on quantitative methods in fishery science [including Beverton's theory of Growth Maturity Longevity and stock assessment methodology]; Ms. Kate Richerson (assistant to Marc Mangel) worked with Mangel and Dr. Phil Levin (Northwest Fishery Science Center) on accounting for indirect effects and non-commensurate values in Ecosystem Based approaches to Fishery Management; two new students (Cheryl Harrison, Ocean Sciences; Lucinda Robledo, Statistics and Stochastic Modeling) and one faculty member (Chris Edwards, Ocean Sciences) joined CSTAR; Dr. Stephanie Carlson completed her NSF Bioinformatics post-doctoral fellowship (supervised by Mangel and Prof. A. Kottas) and assumed her academic position in the Department of Environmental Science, Policy, and Management at UC Berkeley; Mr. Matt Taddy defended his Ph.D. thesis (on Bayesian nonparametric modeling and analysis) and assumed a faculty position at the University of Chicago.

CSTAR involves many students, post-docs, and faculty in research on quantitative population biology for fishery Management. In the period covered by this report members of CSTAR were Ms. C. Boone (Ph.D. student Archaeology), Mr. M. Beakes (staff member, NMFS Santa Cruz Laboratory) Ms. N. Cantu (MS student, CIBNOR, La Paz, BCS, Mexico), Dr. Stephanie Carlson (NSF Bioinformatics Postdoctoral Fellow), Dr. Katherine Cresswell (Post-doctoral scholar), Mr. Edward (EJ) Dick (Staff member, NMFS Santa Cruz Laboratory and Ph.D. student, Ocean Sciences), Prof. Chris Edwards (Faculty, UCSC), Ms. Cheryl Harrison (Ph.D. student, Ocean Sciences), Dr. Xi He (Staff member, NMFS Santa Cruz Laboratory), Ms. Meisha Key (Staff member, California Department of Fish and Game), Prof. Thanassis Kottas (Faculty, UCSC), Dr. Alec MacCall (Staff member, NMFS Santa Cruz Laboratory, Co-director), Prof. Marc Mangel (Faculty UCSC, Co-director), Dr. Steve Ralston (Staff member, NMFS Santa Cruz Laboratory), Ms. Lucinda Robledo (Ph.D. student, Statistics and Stochastic Modeling), Prof Bruno Sanso (Faculty, UCSC), Mr. C. Simon (Ph.D. student, Statistics and Stochastic Modeling), Dr. Susan Sogard (staff member, NMFS Santa Cruz Laboratory), Dr. David Swank (Post-doctoral scholar), Dr. George Watters Staff member, Pacific Fisheries Environmental Laboratory), Mr. Matt Taddy (Ph.D. student, Statistics and Stochastic Modeling), Mr. John Wiedenmann (Ph.D. student, Ocean Sciences, UCSC), and Dr. Will Satterthwaite (Post-doctoral scholar).

CSTAR faculty, students and post-docs continued work on two major grants that CSTAR funds helped leverage: one concerning the implications of climate change on southern ocean krill life histories, krill predators and krill fishery management; the other concerning life history variation in steelhead trout and the implications of water policy for the conservation and recovery of steelhead trout. We also continued to develop Bayesian hierarchical and Bayesian nonparametric methods for quantitative fishery biology. Especially in Bayesian nonparametric methods for fishery problems, we have established a group that has no parallel in terms of depth or breadth.



A Joint Program for Training and Research in Marine Resource Management Modeling

James Wilen (UC Davis)

NOAA Technical Contact: Roger Hewitt (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

The main objective of this program is to facilitate graduate education in the critical need area of marine resource management modeling. The training we are providing includes courses in population dynamics, stock assessment, conservation biology, resource economics and policy analysis, oceanography, and marine ecology. We draw from a student population that includes students trained in biology, ecology, mathematics and statistics, and economics. The program funds the research of students in Ph.D. degree programs in both Ecology and Agricultural and Resource Economics. The curriculum we have created draws on existing courses in both degree programs, with additional seminars and new course development. A unique part of the program is its required crossover courses (e.g. Ecology degree students take fisheries economics and policy analysis courses, Economics students take courses in population dynamics and resource modeling). The program opens up opportunities to engage in collaborative research and thesis projects focused on current resource management modeling issues at the local, national, and global level.

Research Accomplishments

This period, our training involved continued collaboration with past graduates of the program, ongoing research with continuing and finishing students, and new research with students added to the program this year. Hiro Uchida, who finished his Ph.D. during the 2006/07 period, has continued work with Jim Wilen on harvester-managed cooperative fisheries. They completed a quantitative analysis of Japan's nearshore Fishery Management Organizations (FMOs) and the results are reported in a journal article submission and several chapters in a book published by FAO that Uchida co-edited. Joshua Abbott, also finished his Ph.D. degree in Agricultural and Resource Economics (ARE) at UCD under the guidance of Jim Wilen during the 2006/07 period. Abbott and Wilen have continued collaboration on several topics, including bycatch behavior in the Bering Sea groundfish fishery, statistical models of spatial choice by fishermen, and policies for managing recreational fishing. These projects generated one In Press journal article and four more submitted journal articles during the review period.

In addition to Uchida and Abbott, the program also graduated another (fourth) ARE student last year, Jose Cancino. Jose Cancino worked with Jim Wilen, examining harvester-managed cooperatives in the "loco" or false abalone fisheries off the nearshore areas of Chile. Partial results from this research were reported in a journal article and other papers are in progress. Another ARE student, Jay Abolofia has recently joined the training program as a researcher examining the implications of the ITQ-based rationalization program implemented in Alaska's crab fishery. Taylor Chapple is an ongoing program member, in the Ecology Ph.D. program working with Lou Botsford at WFCB on two projects. For the first project, Taylor is developing a new approach to assessing fisheries with only CPUE and size data. He has developed a method for estimating fishing mortality from age structured models and CPUE data, and is attempting to improve that estimate by adding size data collected in port sampling. The primary collaborator thus far for Taylor's work has been Suzy Kohin of NMFS, La Jolla. Taylor is also conducting a mark-recapture study of great white sharks in the Gulf of the Farallons, collaborating with Barbara Block of Stanford's Hopkins Marine Laboratory. Taylor has completed two field seasons and will complete a third this fall. He received an NMFS/Sea Grant Fellowship in Population Dynamics, which will support his research over the next two years. Liz Moffitt, also in the Ph.D. program in Ecology, is working with Botsford at WFCB on a method for assessing the contribution of proposed Marine Protected Areas (MPAs) to sustainability (persistence) of populations. This method was originally developed for species with sedentary adults, and Liz's contribution is to develop the capability to include the effects of juvenile



and adult swimming behavior. The method has been used in the MLPA process. We collaborated with Michael O'Farrell of NMFS on this project and the results appear in a submitted article. We also added a new student, Patrick Kilduff to the Ecology group supervised by Lou Botsford. Patrick is working on two projects, one a tabulation and assessment of data-poor species managed by the state of California, and the other an analysis of coded wire tag data for Chinook salmon along the west coast of North America. He received a fellowship from the University of California CEQI program (California Environmental Quality Improvement) for the next year.



Untrawlable Habitat for Rockfish/Groundfish

Peter Adams (UC Santa Cruz)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

The overall goal of this study is to collect information on demography, distribution and abundance of groundfish species and associated complex, high-relief habitats, and to apply the results to the assessment of the status of groundfish stocks off California. Specific objectives are 1) compare and evaluate in situ and traditional extractive assessment methods; 2) survey groundfish populations in complex habitats; 3) evaluate spatial and temporal variability in demography, abundance and distribution; 4) determine association with, and relationships among, seafloor features and biologic components of habitats; 5) characterize associated fish communities; and 6) advance quantitative understanding of species life histories and benthic community structure/dynamics.

To achieve these goals, project scientists engage in research that integrates four broad areas: conservation biology, population ecology, spatial ecology, and quantitative methods. A wide variety of field sampling and quantitative methods are employed including observational field surveys, statistical analysis, spatial analysis using GIS and remote sensing, development of sampling and statistical methods, development and application of new technologies, and habitat and species assessments.

Research Accomplishments

From visual surveys conducted from a research submersible, we have made significant progress in characterizing the associations of groundfish assemblages with seafloor habitats off California. Our study site on the continental shelf is a likely transition zone for small fishes before they move to their adult, slope habitats. Understanding the importance of these habitats will improve our ability to assess and manage these deepwater fish stocks.

We have described faunal assemblages of fishes based on seafloor substratum types and depth throughout Southern California Bight over the last ten years. Our research implies that substantial harvesting of larger species has helped alter some fish assemblages, allowing dwarf species to thrive. We characterized habitat associations and effect of predators on these dwarf rockfishes inside large MPAs off southern CA. Better inference of predator effects on these prey species will be possible if these MPAs are effective in rebuilding predator biomass.

In partnership with USGS, we are providing our extensive database on seafloor habitat types and the necessary biological expertise to assist with ground-truthing and interpretation of habitat maps as part of the California Seafloor Mapping Project. We have hired Lisa Krigsman as a research assistant to participate in mapping cruises and interface with USGS. Results from this project will benefit resources managers (e.g. California Dep. Fish Game; Pacific Fisheries Management Council; National Marine Sanctuaries; National Marine Fisheries Service) and fisheries and environmental science in general.

With collaborators from MLML, CA Sea Grant, and Washington State University, we are using our submersible survey methods to collect baseline data on fishes, structure-forming invertebrates, and habitats in the deep



portions of eight new MPAs and associated reference sites off Central California. This comprehensive baseline will be used in the future to critically evaluate the effectiveness of the new MPAs by assessing changes in diversity, density, and size composition of species using seafloor habitats in these areas.

We have hired a temporary GIS/Database Technician (Lisa Wertz) to assist in assembling our historic datasets on seafloor habitats and fish and invertebrate assemblages in deepwater from southern and central California. We hired a temporary Program/Analyst (Liz Sassone) to compile data on marine debris (largely discarded fishing gear) that is associated with these seafloor communities and assist in analyzing potential impacts of these data to deepwater seafloor habitats and fishes.

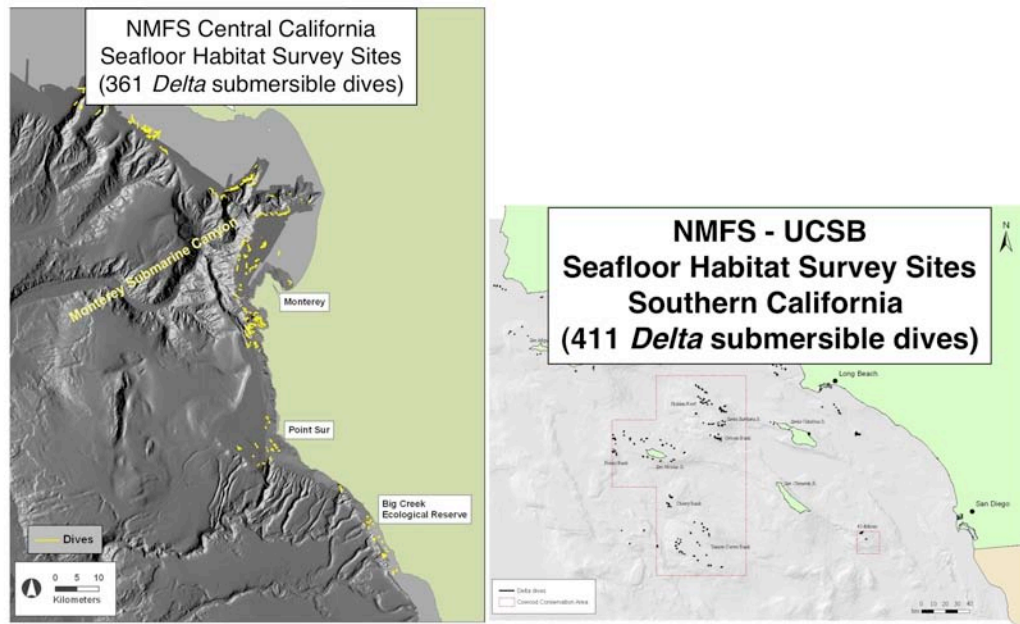


Fig. 1 Locations of 772 dives conducted by NOAA-NMFS and UC Santa Barbara researchers using *Delta* submersible to survey seafloor fishes, habitats, debris, and invertebrates off central and southern California

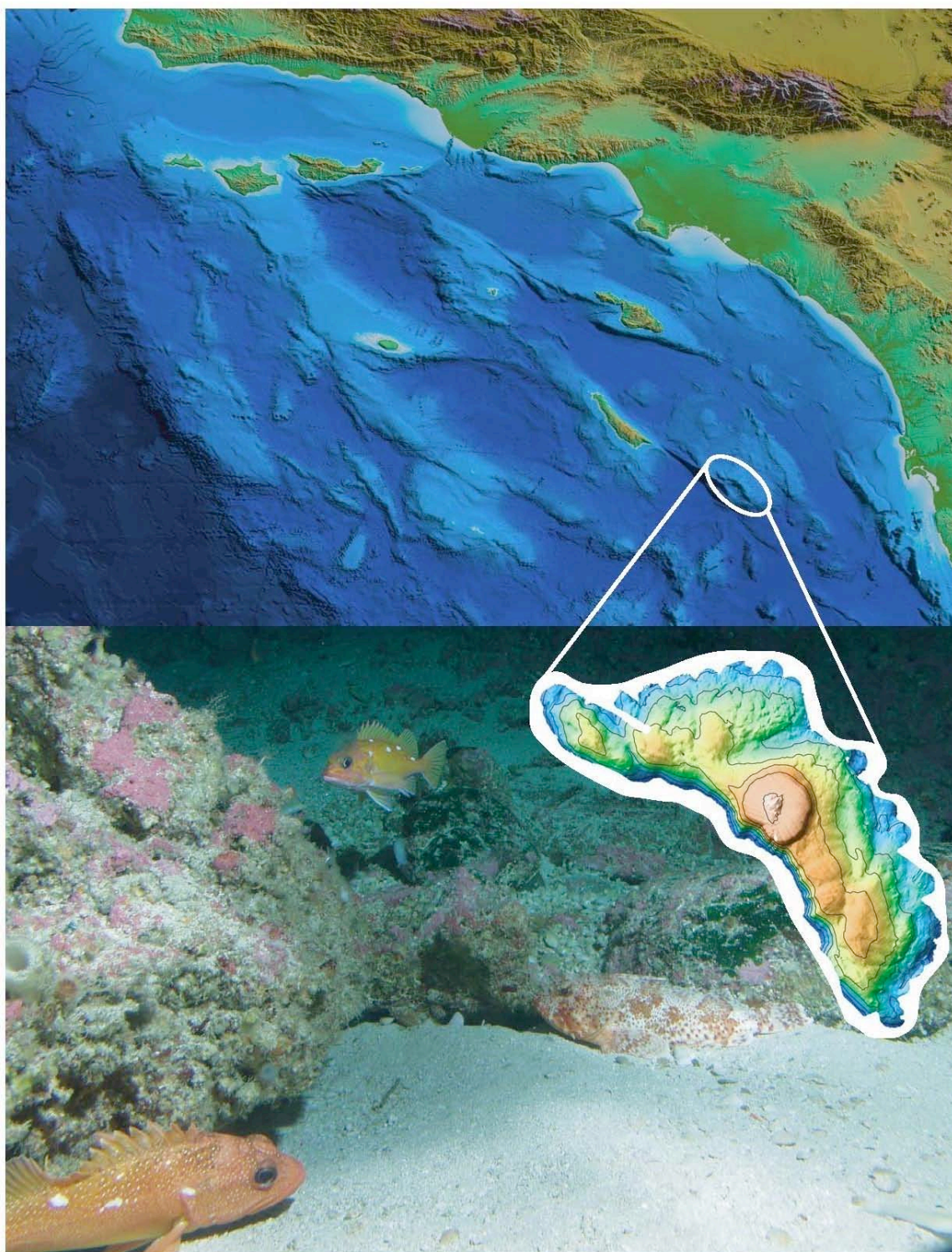


Fig. 2 Images of seafloor habitats in the Southern California Bight, collected on region-wide spatial scales with multibeam acoustic sonar and at small spatial scales with the *Delta* submersible



Cooperative Studies of Pacific Coast Salmon: NOAA Fisheries and the University of California, Santa Cruz

Peter Adams (UC Santa Cruz)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

The salmon research program in the Fisheries Investigation Branch at the NOAA NMFS SWFSC Fisheries Ecology Division consists of the Salmon Population, Landscape Ecology, and Salmon Assessment teams. Their overall objectives are to conduct research needed to support (1) salmonid conservation and recovery planning under the Endangered Species Act (ESA) and (2) management of salmonid fisheries and harvests. Specific goals include: to collect or to coordinate collection of critical population distribution and abundance data needed for assessments of salmonid populations; to establish appropriate and statistically robust survey methods and population estimators for use in salmon research and management; to investigate critical salmon life history characteristics (abundance, distribution, mortality, straying, etc.) needed for a comprehensive management approach to Pacific salmon and steelhead; to develop methods for modeling population viability and metapopulation dynamics for use in ESA assessments; and to provide salmon harvest management guidance, through modeling and focused biological studies.

To achieve these goals, project scientists engage in research that integrates four broad areas: conservation biology, population ecology, spatial ecology, and quantitative methods. A wide variety of field sampling and quantitative methods are employed to achieve specific research objectives, and specific study designs are dictated by the particular hypotheses being tested. Methods include observational and experimental field studies, statistical analysis, spatial analysis using GIS and remote sensing, development of sampling and statistical methods, development and application of new technologies, harvest management models and analysis, life-history analysis using otolith microchemistry, and theoretical ecology/modeling.

Research Accomplishments

Project scientists completed field studies that (1) employed a newly available technique using fiber-optic cable and laser sensor to obtain continuous high-resolution temperature data for over 1 km of stream in the Arroyo Seco basin to document variation in thermal habitats for threatened steelhead, and (2) developed and employed a new method of surveying green sturgeon in rivers using boat-mounted dual frequency identification sonar (DIDSON) to obtain the most complete abundance estimates to date of sturgeon in the Rogue River, Oregon. Staff also continued 5 ongoing field studies: (1) evaluation of a regional monitoring method for detecting endangered coho salmon in streams in San Mateo and Santa Cruz counties; (2) population dynamics and ecology of steelhead in a small coastal basin using mark-recapture methods with Passive Integrated Transponder (PIT) tags and both fixed and portable radio-frequency identification (RFID) antennas; (3) habitat use and movement of green sturgeon using acoustic tags and a network of receivers; (4) survival and migratory patterns of juvenile salmonids in the Central Valley using acoustic tags and receivers; (5) feasibility study on the application of DIDSON for monitoring adult steelhead runs in central and southern California. In addition to these field studies, personnel completed a variety of spatial analyses using GIS to identify potentially suitable habitat for salmonids and sturgeon throughout California, several modeling and statistical projects related to population viability analysis, and salmonid life-history analysis using otolith microchemistry. Staff also initiated five new studies: (1) develop methods using remote-sensing data to improve stream temperature predictions for a large regulated river, (2) develop statistically robust climate model products for estuarine-dependent and anadromous fish stock assessments; (3) identify terrestrial and freshwater influences on anadromous and estuary-dependent fish; (4) determine habitat preferences of green sturgeon in the coastal ocean; and (5) identify habitat utilization and foraging behavior of green sturgeon in a large coastal bay. Finally, project scientists led NOAA Fisheries Technical Recovery Teams, served on Biological Review Teams engaged in conservation and recovery planning for threatened and endangered stocks of anadromous salmonids and



sturgeon, and served on Klamath River Technical Advisory Team and Salmon Technical Team to provide stock assessment and harvest management support.

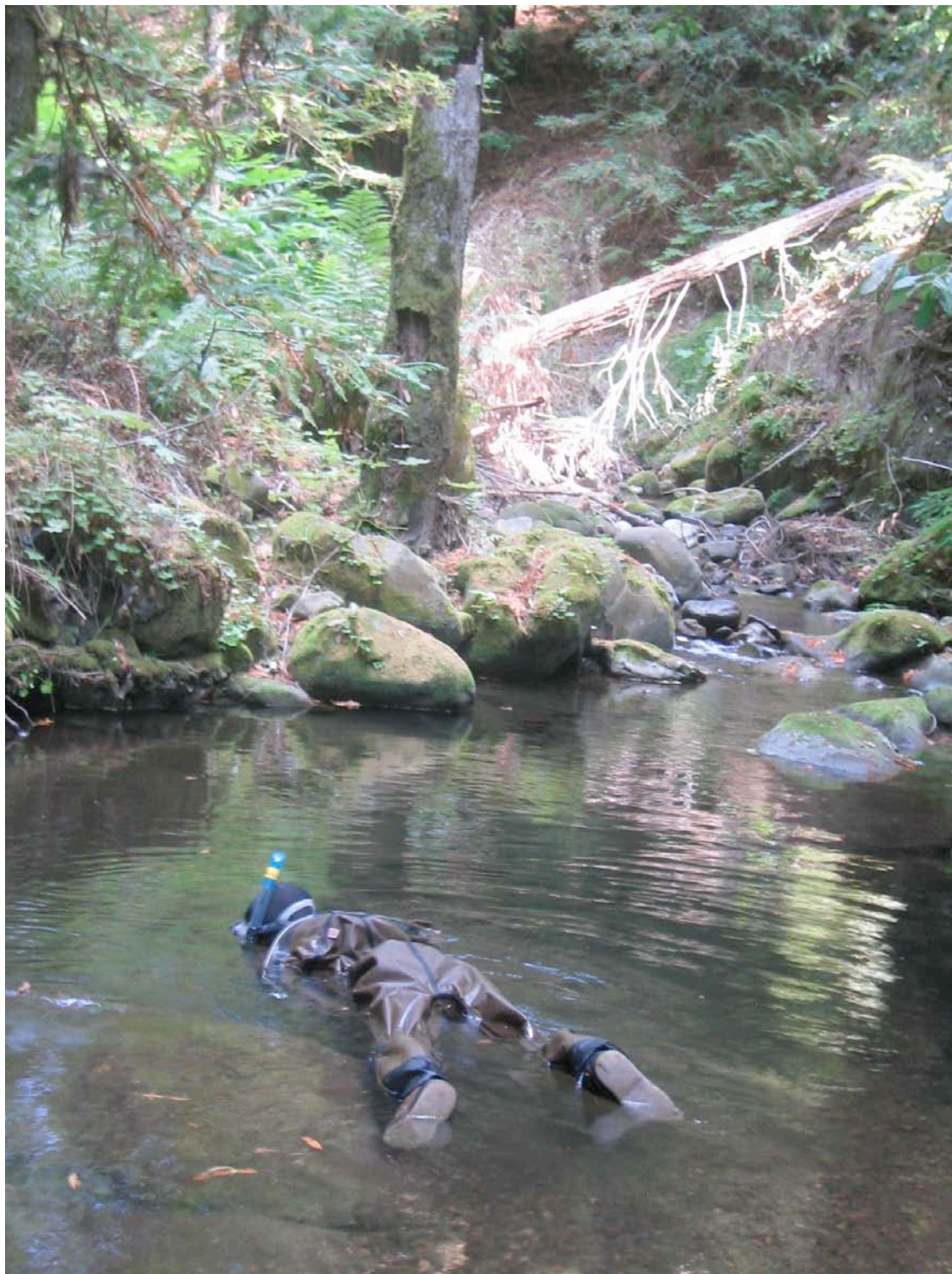


Fig. 1 JIMO researcher conducting snorkel surveys for juvenile coho salmon and steelhead in a coastal stream in Santa Cruz County, California



Fig. 2 Dual-frequency identification sonar (DIDSON) used to count adult coho salmon and steelhead in a coastal stream near Santa Cruz, California



Freshwater Ecology Research Collaboration

Peter Adams and Jonathan Moore (UC Santa Cruz)

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

This funding is part of the start-up hiring package for Jonathan Moore as an assistant professor at University of California Santa Cruz. Thus, the principle objective of this project is to enable the rapid development of a successful research program in Freshwater Ecology led by Dr. Moore. This research program will focus on the ecology of freshwaters and the organisms that live in them, such as anadromous fishes. One desired aspect of this research program is active collaboration with NOAA research teams. These funds should be used to build up the equipment and supplies needed for the research program as well as to jump-start project initiation.

Several actions are required to achieve these goals. First, equipment and supplies needed for field and laboratory studies will be researched and purchased. Second, collaborations with NOAA researchers will be initiated, including active pursuit of funding. Third, preliminary projects will be initiated that will be the basis for future work and funding.

Research Accomplishments

Dr. Moore and his group have made substantial progress in developing their lab focused on freshwater ecology. Equipment and supplies have been purchased so that now the Moore lab can perform needed field and laboratory studies and analyses. Since starting here at UC Santa Cruz, Dr. Moore has continued to publish in high-level journals.

Dr. Moore has also initiated several projects focused on stream ecosystems. Specifically, in collaboration with NOAA (Sean Hayes) and UC Berkeley (Stephanie Carlson), the Moore lab is performing a large-scale experiment with steelhead and crayfish in upper Scott Creek to examine how these two stream animals impact benthic and water column components of streams. Furthermore, in collaboration with Hayes and others, the Moore lab received a grant from California Sea Grant to investigate the impacts of avian predation on steelhead in coastal streams such as Scott and Waddell Creek. A new graduate student (Ann-Marie Osterback) is now supported by this collaborative project and started this summer. Dr. Moore also received a Sea Grant project development grant in collaboration with Carlson to initiate studies of the invasive New Zealand mudsnail, which has recently invaded California streams, and may disrupt flows of energy through stream food-webs. These projects reflect successful collaborations with NOAA researchers as well as the start of attaining future funding for Dr. Moore's research program.



Shipboard Monitoring of the California Current System Off Central California

Baldo Marinovic (UC Santa Cruz), Francisco Chavez¹ and Curtis Collins²

- 1) Monterey Bay Aquarium Research Institute
- 2) Naval Postgraduate School

NOAA Technical Contact: Churchill Grimes (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

In cooperation with the NMFS, we propose to continue quarterly shipboard measurements along CalCOFI Lines 60 and 67 through August 2008. The NOAA Ship *David Starr Jordan* would make measurements for the fall cruise and the *R/V Pt. Sur* will be utilized in the summer cruise. Measurements In Fall 2007 and Summer 2008 will consist of CTD/rosette casts, plankton tows, VMADCP current observations, and continuous underway measurements of sea surface and meteorological parameters. Seawater will be assayed for nutrients (nitrate, nitrite, phosphate and silicate). Water samples in the upper 200 m will also be assayed for chlorophyll-a, primary production, phytoplankton taxonomy and cell counts. Vertical and horizontal zooplankton sampling will include standard bongo oblique tows to 210 m depth as well as surface manta tows. Samples will be preserved in 10% buffered formalin/seawater and processed post-cruise in the laboratory. Biovolume displacements will be initially determined and then samples will be archived at SIO where taxon specific processing will be conducted by various research groups. All data collected on the fall and summer cruises will be made available as soon as possible to other researchers via web based archives and technical reports.

Research Accomplishments

During the period between August 2007 and the summer of 2008, in cooperation with NMFS, quarterly shipboard measurements along central California were continued in an effort to further understand the relationship between physical circulation and biological consequences in this critical region that the site for the majority of the nutrient input to the surface waters of the California Current System.

Additionally this work also supported the collection and analysis of chlorophyll-a and nutrients for the northern lines occupied by the NOAA Ship *David Star Jordan* during the winter and spring CalCOFI cruises of 2008.

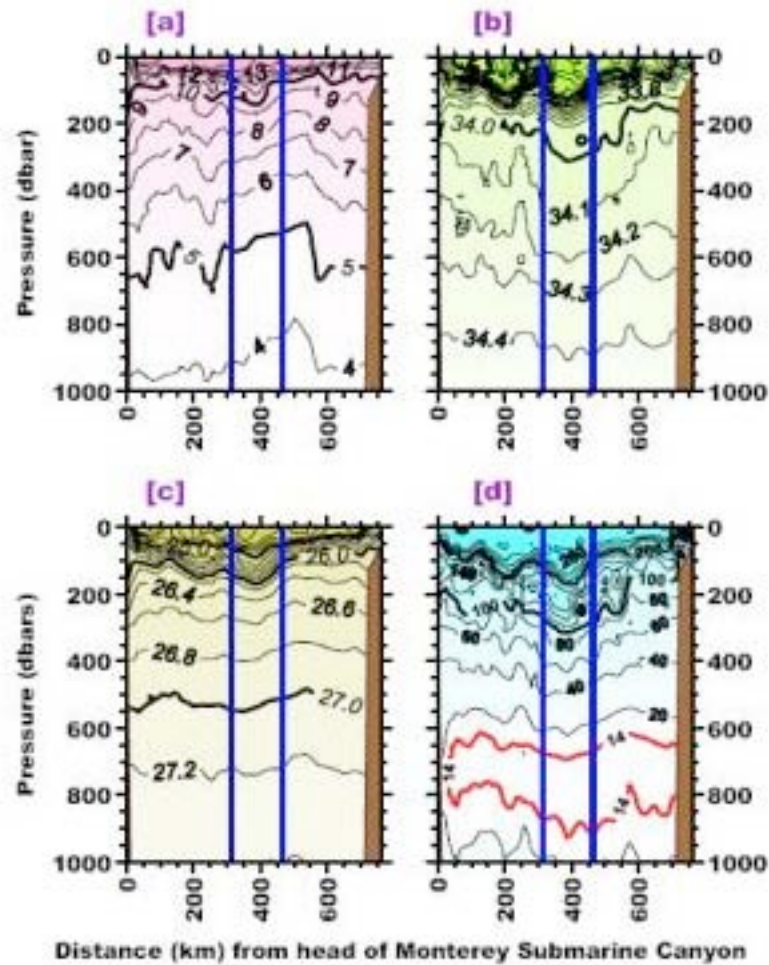


Fig. 1 Contours of (a) temperature ($^{\circ}\text{C}$), (b) salinity, (c) density anomaly (kg m^{-3}), and (d) oxygen ($\mu\text{mol kg}^{-1}$) fields along the line of hydrographic stations from Moss Landing (on the left) to Drake's Bay, California. The blue lines indicate the locations of the corner hydrographic stations (CTDs 18/19 and 23). Contour intervals for panels a-d are 1°C , 0.1 , 0.2 kg m^{-3} , and $20 \mu\text{mol kg}^{-1}$, respectively, except that the (nearly) oxygen minimum contour of $14 \mu\text{mol kg}^{-1}$ is highlighted in red in panel d

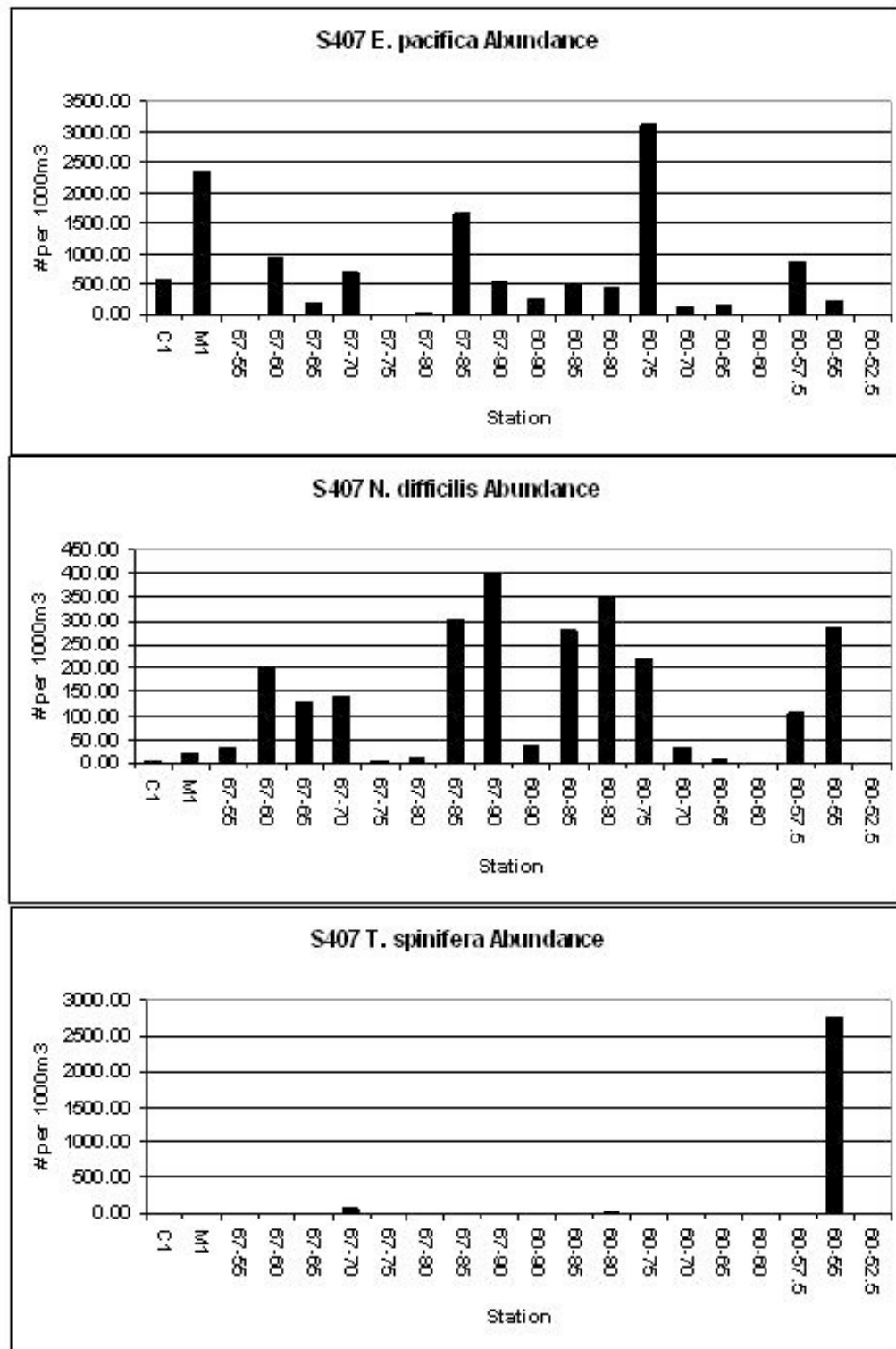


Fig. 2 Krill abundance for the three most common species collected at stations sampled along CalCOFI lines 67 and 60 during the PaCOOS cruise of November 2007. Top = *Euphausia pacifica*, middle = *Nematoscelis difficilis*, and bottom = *Thysanoessa spinifera*. Note that the y-axis scale differs for each graph



Phytoplankton Studies in Cooperation with the U.S. Antarctic Marine Living Resources (AMLR) Program, January–March 2007

Osmund Holm-Hansen (SIO)

NOAA Technical Contact: Rennie Holt (NMFS/SWFSC)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

The overall objective of our research project was to assess the distribution and concentration of food reservoirs available to the herbivorous zooplankton populations throughout the AMLR study area during the austral summer. The specific objectives of our work were:

- (i) To determine the distribution, biomass, and size distribution of phytoplankton in the upper water column (surface to 200m), with emphasis on the upper 100m,
- (ii) To determine or estimate the rate of primary production in the water column,
- (iii) To better our understanding of the reasons for the variability in distribution of phytoplankton in relation to dynamic physical processes, nutrient concentrations, and solar irradiance in the upper 100 m of the water column.

These objectives were obtained by the following observations/measurements/methods:

- (i) Chlorophyll-a concentrations were measured in water samples from depths of 5, 10, 15, 20, 30, 40, 50, 75, 100, and 200 m at 102 stations during Leg I and 117 stations during Leg II.
- (ii) Water samples were taken for measurement of macronutrient concentrations (N, P, and Si) at 10, 30, 50, 75, 100, and 200 m target depths at 10 stations during Leg I and 62 stations during Leg II.
- (iii) Water Column Trace Metal Concentrations: uncontaminated water samples for trace metal analysis were collected at 17 stations from various depths, and will be processed by Murat V. Ardelan (Norwegian University of Science and Technology).
- (iv) Profiles (5-200 m) of chl-a, in situ chl-a fluorescence, beam attenuation, and solar irradiance at all stations.
- (v) Phytoplankton taxonomy: Water samples for microscope analyses were obtained at 27 stations in Leg I and 74 stations in Leg II. These samples were delivered to J. L. Iriarte (Universidad Austral de Chile, Puerto Montt, Chile) for analysis.
- (vi) Water column profiles (temperature, salinity, density) in relation to water zones.
- (vii) Mean chlorophyll-a Concentrations in the four AMLR survey Areas.

Research Accomplishments

Our usual survey area is limited to the South Shetland Islands area lying north of the tip of the Antarctic Peninsula. This year, to celebrate the International Polar Year (IPY), the US Antarctic Marine Living Resources (AMLR) program extended the survey grid to include (for the first time) the South Orkney Islands area (Leg II). During the first half of January, chlorophyll-a concentrations were high (>0.5 mg m^{-3}) in the waters surrounding the South Shetland Islands and extending into the Elephant Island and southwestern Scotia Sea region. By the second half of January, and corresponding in time with the bulk of the AMLR survey work during Leg I, the highest chlorophyll-a concentrations in Bransfield Strait and the Scotia Sea had diminished considerably. Stations with the lowest surface chlorophyll-a concentrations (<0.2 mg m^{-3}) were found in pelagic Drake Passage waters.

Mean chlorophyll-a concentrations in the UML during Leg I were lowest (~ 0.7 mg m^{-3}) north of the South Shetland Islands and comparable to the values measured during Leg II. Surface chlorophyll-a values were



generally equal to or slightly less than the historical mean values. Highest mean values (1.0 mg chlorophyll-a m⁻³) were in Bransfield Strait during Leg I, which were slightly higher than the historical mean. During Leg II the distribution of phytoplankton showed extremes from low to high concentrations of chlorophyll-a in each of the South Orkney, Elephant Island, and Bransfield Strait areas. For the South Orkney Area, lowest biomass was found over the southern and southeastern shelf, while highest concentrations were found offshore of the northern shelf.

Variability in chlorophyll-a concentrations in the water column is partially explained by the depth of the upper mixed layer (UML). Deep mixing of presumably iron-rich waters along the Peninsular coast and around Elephant Island are associated with low biomass, but in the South Orkney Area, low chlorophyll-a concentrations were found over the southern shelf that had some of the shallowest UMLs of the entire survey. The mean depths of the UML in the four areas of the routine AMLR sampling grid ranged from 57 to 135 m, which were considerably deeper than the 37 m UML depth in the South Orkney region during Leg II. All areas in both Legs had colder and saltier surface waters than normal, and, with the exception of the Joinville Island area in Leg I, also had deeper than average depths for the UML. The integrated chlorophyll-a values over the depth of the UML accounted for >80% of the chlorophyll-a integrated to 100 m depth, with the exception of the South Orkney area where chlorophyll-a below the upper mixed layer accounted for 48% of the integrated chlorophyll-a value. These physical and biological data suggest that the outflow from the Weddell Sea was stronger in 2008 than the norm from past years.

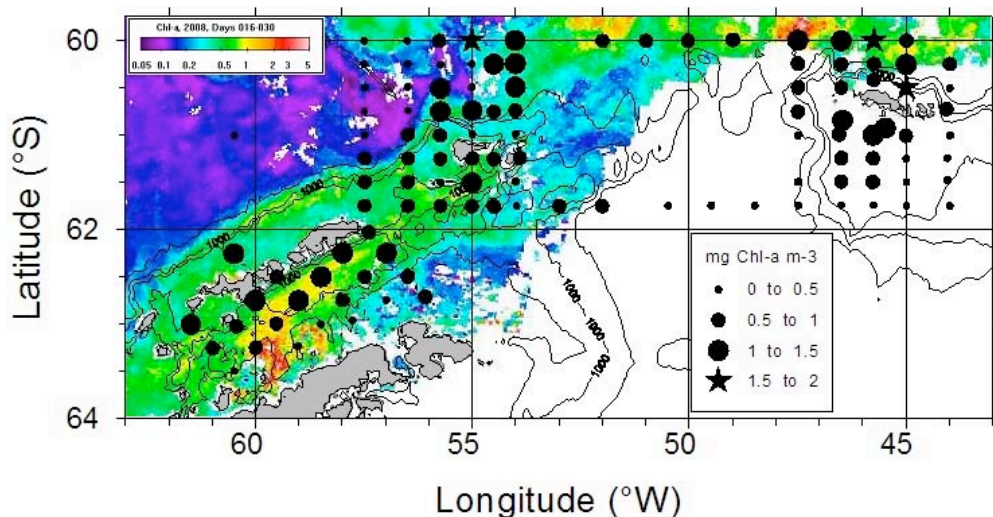


Fig. 1 Surface chlorophyll-a concentrations measured over the South Shetland Islands and South Orkney Islands (Antarctica) during the International Polar Year (IPY) AMLR survey during Feb-Mar, 2008 (symbols, with key). This is superimposed upon a MODIS-Aqua satellite derived Chl-a distributions for January, 2008 (color scale indicates concentration). White areas represent either sea ice or open water areas with insufficient data owing to cloud cover



Historical Ecology of Florida Keys Coral Reef Ecosystems

Jeremy Jackson (SIO)

NOAA Technical Contact: Catherine Marzin (NMSP)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

The objective of this research is to document changes in abundances of coral reef associated organisms in the Florida Keys and establish historical baselines of abundance and distribution. The first phase of the project, completed in 2006-2007, was to locate and digitally archive historical documents, which were located in archives around the world. We completed this phase of the project and summarized the results in a NOAA report, "Sources Survey: The Historical Ecology of the Florida Keys Coral Reef Ecosystem." The goal of the second phase of the project, undertaken during the current reporting period, was to extract relevant data and analyze changes in population abundances and distribution. Specifically, we created a database of historical (1760-1985) references to the abundance and distribution of coral reef associated fishes, invertebrates mammals, birds and reptiles. We have begun to analyze these data and to assess relative abundance of populations and have completed three of four analyses. The results of these data will be useful for managing biological and cultural resource in the Florida Keys National Marine Sanctuary.

Research Accomplishments

We have completed data collection and extraction and have begun data analysis. We created a database of historical (1760-1985) references to the abundance and distribution of coral reef associated fishes, invertebrates mammals, birds and reptiles and have begun to analyze these data. To date, one book chapter has been published based on this research, two journal articles have been submitted for publication, and one more is in process. The research has been reported at scientific conferences, including the American Association for the Advancement of Science (AAAS) and International Coral Reef Symposium (ICRS).



Monitoring Cetacean Response to Ship Noise Near the Channel Islands National Marine Sanctuary

John Hildebrand (SIO)

NOAA Technical Contact: Sue Moore (NMFS)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

NOAA Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

Research Objectives and Specific Plans to Achieve Them

The main objective of our research is to understand the acoustic environment in Channel Islands National Marine Sanctuary focusing primarily on anthropogenic sound generated by commercial ship traffic and the potential impact on marine mammals. The presence nature of commercial shipping within and near the sanctuary results in significantly elevated ambient noise levels. Our study provides measurements to document ambient noise, identifies the most pervasive noise sources, provides a detailed understanding of how marine



mammals use the sanctuary, and outlines potential noise impacts on marine mammals. Our study uses passive, broadband, High-frequency Acoustic Recording Packages (HARPs) to record contributions to the acoustic environment from both biological and human sources. In addition to recording ambient noise levels, and sounds from ships and cetaceans, temporal patterns of their occurrence are also recorded. Recorded ship sound levels are identified using ship-passage records which provide sound level comparisons between ships. The results of this research aims to advance scientific understanding of human noise in the marine environment, inform policy decisions for noise in the sanctuary, and serve as a model for addressing noise pollution in other marine sanctuaries.

Research Accomplishments

Our analyses of ambient noise levels in the Santa Barbara Channel from July to October 2007 showed elevated levels when compared to other regions, both coastal and offshore. The four month average of acoustic energy in the Santa Barbara Channel when local ships were not present shows that the sound levels in the low frequency band (10-1000 Hz) ranged from 56-90 dB re: 1 μ Pa²/Hz. During this period the blue whales calls are a dominant source of sound and are elevated above the background by 10 dB re: 1 μ Pa²/Hz at 16 Hz (the fundamental frequency of the blue whale B song call). When local ships are present (within 4 km) sound pressure levels increase by 15-25 dB compared to periods when no local ships are present. Blue whale calls are no longer above the background levels when a ship is within 4 km of the recording instrument. Based on detections of local ships in the acoustic data, there are approximately 18.8 (\pm 10.8) commercial ships per day compared to 9.5 (\pm 4.6) ships detected by the Automatic Information System (AIS) that tracks ships via VHF signal. The average speed from the AIS over this four month period was 16.4 (\pm 5.7) knots (8.4 m/s) in the North and Southbound lanes. The duration that sound pressure levels are elevated depends mainly on the size and speed of the ship (i.e. how much acoustic energy is put into the environment); the average duration that levels were elevated by at least 15 dB averaged 10 minutes. Through a simple calculation we determined the hours of elevated noise levels per day: Number of ships per day (from acoustic data) * length of passage/ 60 = Hours of elevated noise levels.

For the Santa Barbara Channel from July- October 2007, the ambient noise levels are elevated by 15-25 dB for an average of 3.1 hours per day.

Based on an analysis of time of day that ships passed near the HARP, the increased levels of noise do not appear to be evenly distributed throughout the day. There are distinctive peaks in shipping activity at noon and midnight, most likely related to port activities and schedules.

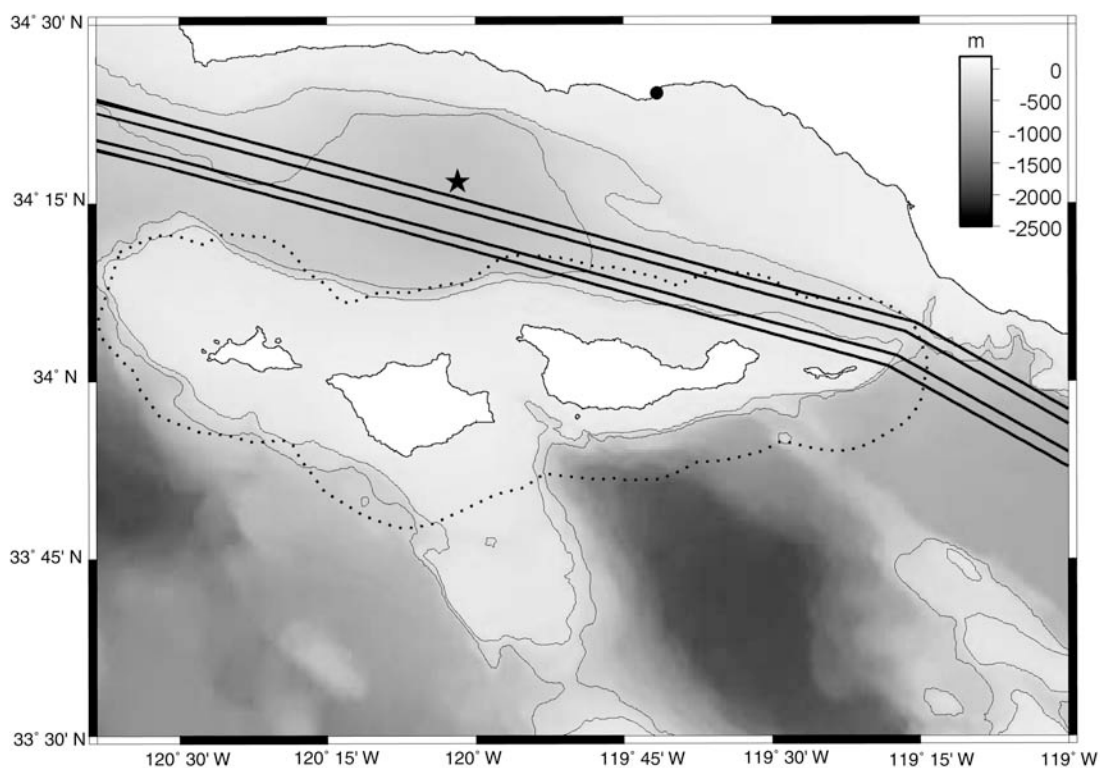


Fig. 1 Map of Santa Barbara Channel and the Channel Islands National Marine Sanctuary (CINMS). The dotted line represents the borders of CINMS. The star is the location of one of the seafloor HARPs in the Santa Barbara Channel. The contour lines are at 200 and 400 m. The circle represents the location of the AIS receiver in Santa Barbara harbor. The solid black lines show the commercial shipping lanes

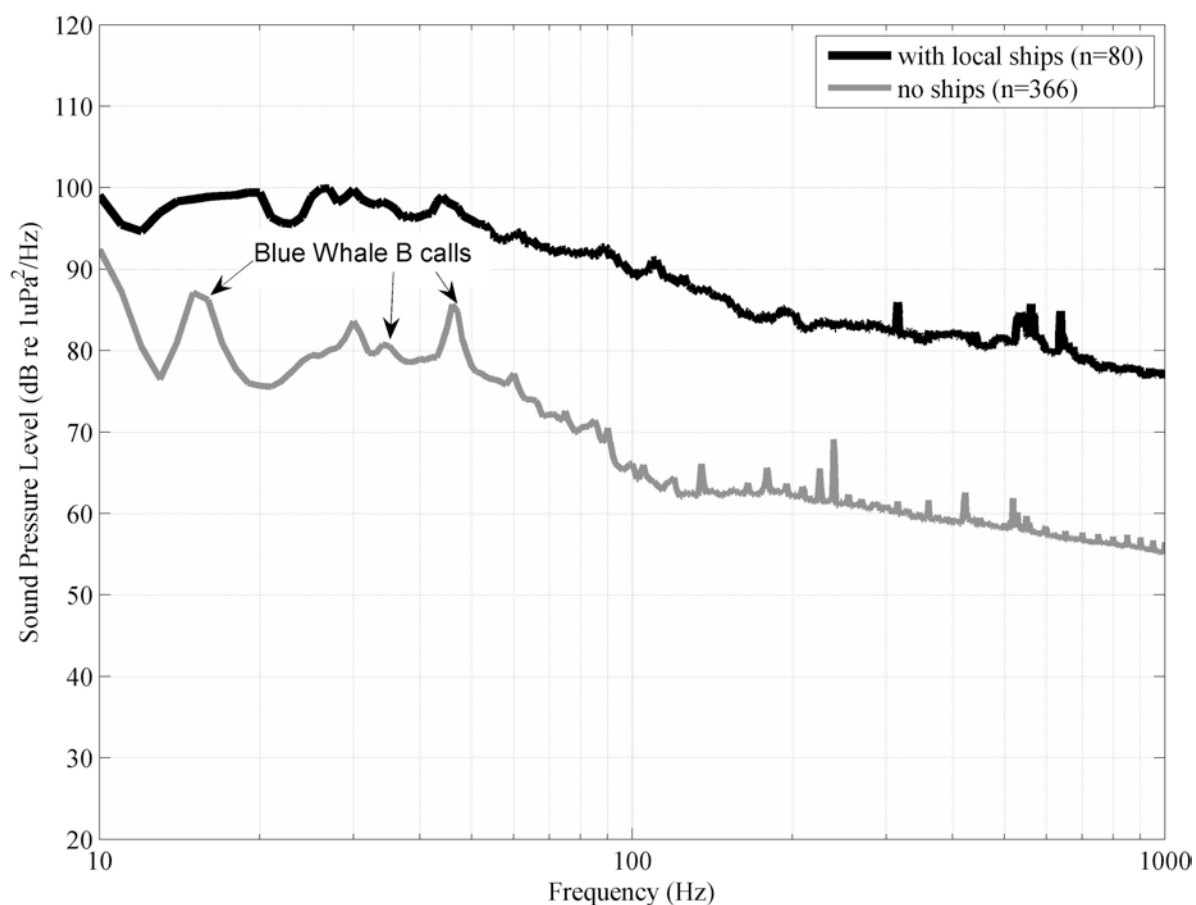


Fig. 2 Comparison of sound pressure levels in the Santa Barbara Channel when ships are present (<4 km) and ships are not present (>9 km). The data are from July 2007 to October 2007. Blue whale calls are detected when a ship is not within 4km



Measurement and Modeling Analysis of Organic Aerosol and Their Cloud Interactions

Lynn M. Russell (SIO)

NOAA Technical Contact: Ed Dunlea (CPO)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

Research Objectives and Specific Plans to Achieve Them

This proposal supports (1) continued and enhanced measurements of submicron particle composition using FTIR spectroscopy, XRF spectroscopy, and AMS measurements to obtain elements, functional groups, and quantitative organic mass as part of NOAA field studies, (2) extended NEXAFS/STXM of organic functional groups and their distribution in single particles as part of NOAA field studies, (3) development and implementation of process modeling and laboratory measurements incorporating the phase, mixing state, and optical properties of the measured organic bonds, using model compounds and their measured properties, and (4) training personnel to operate the AMS in an upcoming field study.



Research Accomplishments

Our analysis of aircraft measurements collected during the Dynamics and Chemistry of Marine Stratocumulus-II (DYCOMS-II) experiment showed that all of the 18 measured chemical components partitioned between the particle and droplet phases in similar proportions within each of the 6 research flights studied. The partitioning ratio (mass scavenging coefficient) was also similar between the research flights. Together these results indicated that the particles were internal mixtures of sea salt, sulfate, organics, and mineral components and therefore activated to cloud droplets based on their size and unique chemical composition. These results are consistent with the meteorological conditions recorded during the study and the physical properties of the particles, i.e. size and number. The completed analysis was accepted for publication.

During summer 2006 shipboard measurements of particles in or near the Houston ship channel were collected as part of the Texas Air Quality Study-II (TEXAQS-II). These measurements have been used to characterize the ambient particles by their organic functional group composition and their elemental composition. Saturated C-C-H and unsaturated aliphatic carbon C=C-H compose a large fraction of the organic mass near the Houston ship channel. The fraction of OM from the two oxidized organics carbonyl C=O and organic hydroxyl C-OH increased with distance from the center of pollution, indicating aged or processed organic aerosol particles. The organic mass was highest near the last third of the campaign when the research vessel was in the Houston ship channel. Positive matrix factorization has been used to cluster the organic functional group spectra into groups; the elemental composition of the resulting clusters is consistent with the organic functional group spectra. Comparisons between organic mass (OM) from our measurements and Aerosol Mass Spectrometer (AMS) organic mass are currently in progress, and we expect to complete a manuscript for submission shortly.

In preparation for the Variability of the American Monsoon System (VAMOS) Ocean-Cloud-Atmosphere-Land Study (VOCALS) research cruise scheduled for October and November 2008, an Aerosol Mass Spectrometer and facilities for organic and elemental filter measurements are being tested and calibrated on the Scripps Pier as training for the VOCALS campaign. In addition to training, these measurements will provide quantitative chemical information on coastal marine stratocumulus, similar. The Aerosol Mass Spectrometer (AMS) has been calibrated and moved to a temperature controlled housing on the Scripps Pier.

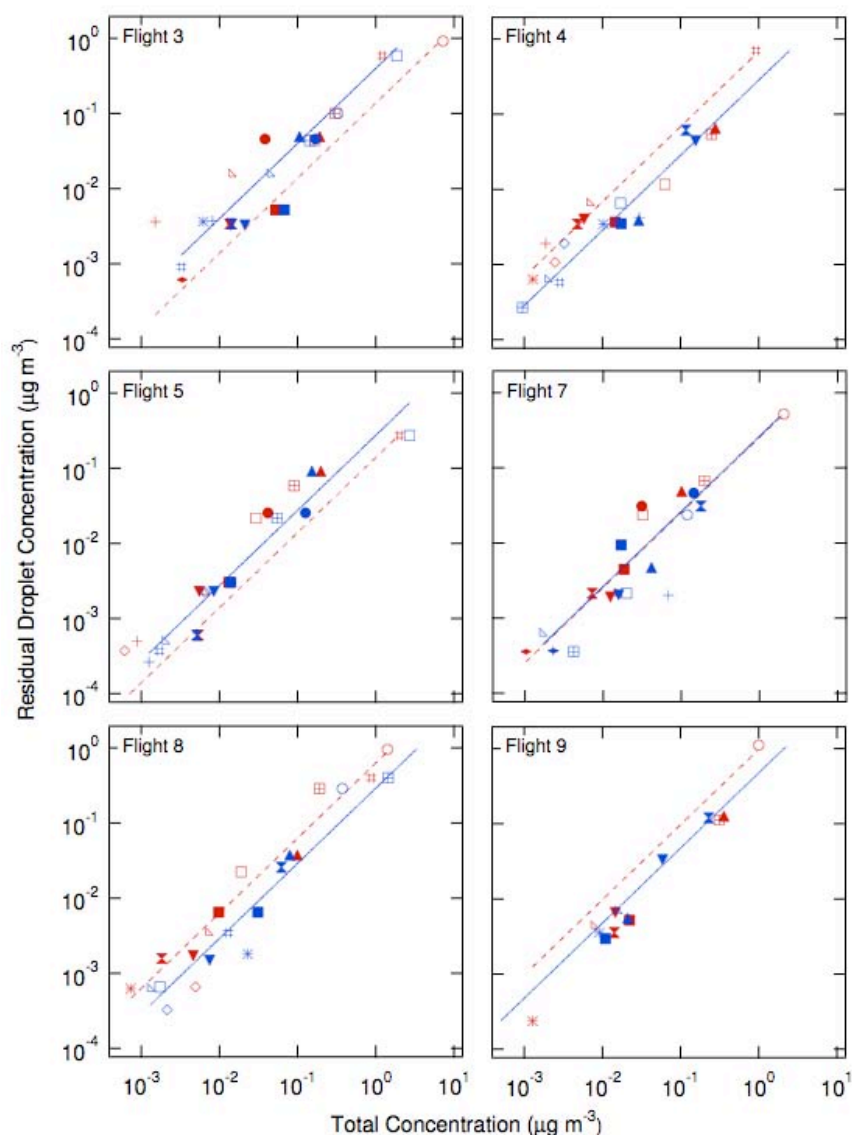


Fig.1 Panels contain the mass scavenging coefficient plots. Concentrations of components in droplet residuals are plotted on the ordinate (CVI); total concentrations in and below-cloud level are plotted on the abscissa. Markers show: aluminum (solid red bowtie), silicon (solid blue square), sulfur (solid green upward triangle), potassium (solid turquoise vertical bowtie), calcium (solid orange downward triangle), vanadium (purple asterisk), iron (open black triangle), ammonium (open turquoise quartered square), sulfate (open pink circle), titanium (open grey narrow diamond), manganese (red x-cross), cobalt (open blue diamond), organosulfur C-O-S (open green circle with plus), nickel (solid dark red wide diamond), carbonyl C=O (open orange circle with x-cross), silicate (open purple square), aliphatic C-C-H (black pound), copper (open turquoise diamond), chromium (pink plus), and chlorine (solid grey circle). Blue markers and the blue solid fit line represent flight-averaged concentrations within the cloud, the red markers and the red dashed fit line represent below cloud samples. Scavenging coefficients, F , range from 0.14 to 0.97 below cloud and 0.26 to 0.40 in cloud



Interannual Variability of Small Pelagic Spawning Habitat in the California Current

David Checkley (SIO)

NOAA Technical Contact: Frank Schwing
(NMFS/SWFSC/PFEG)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

To define the spawning habitat of the Pacific sardine in waters off central and southern California using empirical data on fish egg distributions and the environment, the latter including observations using satellites.

Research Accomplishments

The majority of this research has not yet been performed, but two options for the completion of the work have been identified, one of which will be pursued during the next reporting period.

One activity that has been performed is the writing of a manuscript, led by NOAA scientist Dr. Christian Reiss, on the use of satellite data to estimate the spawning habitat of sardine and anchovy off central and southern California. This paper shows that a model of spawning habitat with input variables of satellite-derived sea surface temperature and ocean color currently provides a good prediction of the spawning habitat used by the Pacific sardine but greatly overestimates the spawning habitat used by the northern anchovy. Sardine is at high abundance and anchovy at low abundance presently and we believe this may affect the extent to which available habitat is used by these two species.

A second activity has been the analysis of a dataset from 1998-2004 on the spawning habitat of sardine and anchovy. Kernel density estimation has been applied to these data to characterize the conditions in which spawning occurred. This work remains in progress.

A final activity has been the characterization of sardine spawning habitat by use of satellite and model-measured winds and a theory of pelagic ecosystems. This resulted in a manuscript which shows how anchovy are adapted to coastal, wind-driven upwelling and sardine are adapted to offshore, wind-stress curl driven upwelling.



THEME C: RESEARCH IN EXTREME ENVIRONMENTS



Methane Seeps Under Hypoxia: Novel Ecosystems within Eastern Pacific Oxygen Minimum Zones

Lisa Levin and Peter Lonsdale (SIO)

NOAA Technical Contact: Jeremy Potter (OE)

Links to NOAA Strategic Plan:

NOAA Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through an Ecosystem Approach to Management

Research Objectives and Specific Plans to Achieve Them

Most of the deep sea floor remains unexplored, even in close proximity to human population centers. Naturally occurring environmental stressors in the bathyal deep sea include low oxygen and the seepage of methane and sulfide. Unusual and novel ecosystems in the deep sea are often found where these stressors exist. This project is intended to explore the benthic communities that develop where methane seepage and attendant high sulfide concentrations intersect with the natural hypoxia associated with global oxygen minimum zones (OMZs). Our focus has been the study of OMZ sediments off Mexico (2005), methane seep and OMZ sediments in the Pacific Northwest (CA and OR July/Oct. 2006), off Chile (Sept. 2006, Sept./Oct. 2007) and off New Zealand (Nov. 2006/Feb. 2007). Research was conducted aboard US, Mexican, Chilean New Zealand and German research vessels with a combination of ship-based sonar, bottom photography, multicoring, box coring, trawling, dredging and a submersible. Our objectives were to (a) locate and survey novel seep or OMZ ecosystems, establishing their geologic and hydrographic setting, (b) document the distribution of reducing communities in relation to geological surroundings and the ambient sea floor communities (c) quantify the abundance, trophic structure and composition of seep macrofaunal assemblages and compare them to nearby oxygen minimum zone communities.

This research will advance understanding of biotic response to hyper-stressed conditions (sulfide toxicity and hypoxia), expand known biogeography of reducing ecosystems, yield insight into the roles of habitat heterogeneity in generating and maintaining continental margin biodiversity, and a window to evolution within ultra-extreme environments. These studies will broaden our understanding of seeps as unusual environments, expand our views of marine biodiversity and contribute much needed biogeographic data for the macrofauna of Pacific deep-sea ecosystems. Major foreign partners are Elva Escobar, Universidad Nacional Autonoma de Mexico (UNAM, Mexico), Javier Sellanes (Univ. Catolica del Norte, Chile) and Ashley Rowdan (NIWA, New Zealand). Major US partners are Wiebke Ziebis (University of Southern California), Amy Baco (Florida State University), and Craig Smith (U. Hawaii).

Research Accomplishments and Results

Recently, during explorations of the upper slope of central Chile, a new methane seep site was discovered at unexpectedly shallow water depth (~350 m) located off El Quisco (~33° S). The presence of a cold-seep community is indicated by articulated valves of a vesicomyid species of the genus *Calyptogena* s.s., tubes of a siboglinid polychaete of the genus *Lamellibrachia*, and abundant blocks of authigenic carbonate. This new site is a cold seep within the influence of an Oxygen Minimum Zone (OMZ), offering a unique opportunity of studying the interaction of both low oxygen and methane seepage. Preliminary results suggest this site has a higher faunal abundance and diversity than adjacent sites, and that some of the constituents of this fauna are



commercially valuable fishing resources (e.g. the shrimp *Heterocarpus reedi* and the yellow squat lobster *Cervimunida johni*).

Additional effort this year has focused on characterization of OMZ macrofaunal communities from the California and Oregon margin based on sampling at 500, 800, 900, 1000, and 1200 m in relation to seep assemblages (at 500 m and 800 m). Methane seeps enhance margin biodiversity. Off California at 500 m we have found 42 species off seep (within the OMZ), 82 species in clam beds (20 unique), 49 species in microbial mats (6 unique) and 60 species in near seep sediments. About 34% of the infaunal seep taxa in clam beds also occur in margin sediments completely outside the seeps. Both seep and non-seep margin biodiversity are lower at 800 m off Oregon, where bottom-water oxygen concentrations are < 0.3 ml/l.

Finally, we are continuing the stable isotope-based study of trophic structure at New Zealand methane seeps. Variation in methane use by heterotrophic fauna appears to reflect the availability of hard vs. soft substrate; with heavy $\delta^{13}\text{C}$ signatures of macrofauna on and in hard substrates reflecting consumption of plankton. Two unique, biogenic assemblages were discovered to be fueled largely by methane; a hard-substrate sponge community and a soft-sediment assemblage dominated by ampharetid polychaetes. Isotope signatures of associated macrofauna yield estimates of 38 -100%, and 18 - 76 % of methane-derived carbon in macrofaunal tissues of sponge and ampharetid beds, respectively.



THEME D: RESEARCH & DEVELOPMENT ON OBSERVATIONS SYSTEMS



Joint Project Agreement Concerning the National Spatial Reference System in California

Yehuda Bock (SIO)

NOAA Technical Contact: Gilbert Mitchell (NGS)

Links to NOAA Strategic Plan:

NOAA Goal 4: Support the Nation's Commerce with Information for Safe,
Efficient, and Environmentally Sound Transportation

Research Objectives and Specific Plans to Achieve Them

NOAA's National Geodetic Survey (NGS) and the California Spatial Reference Center (CSRC) have joined in partnership for the purpose of researching precise spatial referencing and height modernization for the public good. Although focused on California, our goal is to contribute directly to the development by the NGS of public guidelines and procedures for other states and entities interested in implementing height modernization and spatial reference systems. The specific objectives of the project are to research and implement the scientific and infrastructure basis for the California Spatial Reference System (CSRS). There are several outstanding research questions related to spatial referencing that are being addressed:

- (1) What is the proper observation mix to maintain a modern height network within a spatial referencing environment, and how should these measurements be optimally combined? Observation types include continuous GPS (CGPS), field GPS surveys at passive monuments, spirit leveling, and gravity surveys.
- (2) What is the proper mix of geoid models and local corrector surfaces, in converting from GPS-determined geodetic heights to orthometric heights?
- (3) Can we apply and enhance modern IT methods to provide timely access to height modernization and spatial referencing information?
- (4) How does one develop and implement a precise GIS for the purposes of height modernization and spatial referencing?
- (5) How can real-time (RT) CGPS networks, such as those being created in California, be best used to directly support height modernization and spatial referencing?

The CSRC has been established to achieve the above research objectives. The R&D and operational arm of the center is located at Scripps, and leverages the resources of the Scripps Orbit and Permanent Array Center (SOPAC). The CSRC also consists of an Executive Committee, Coordinating Council, and a user community, organized as a UCSD Support Group. Along with our sponsors at NGS, the Executive Committee provides advice on the research direction, the relevant civil applications, and the allocation of resources. The overall success and management of the project is the responsibility of Y. Bock.

Research Accomplishments

We worked on the North San Joaquin 2006 Project and the Central Coast Height Modernization Project 2007-2008, as part of the CSRC's Master Plan to maintain the California Spatial Reference System (CSRS). We used an enhanced version of the Pocket GPS Manager (PGM), including version 1.2 of the PGM client software), a modern server/client application for planning, executing, analyzing, visualizing and archiving geodetic control, height modernization and crustal motion projects (Figure 1).



We incorporated into the SOPAC/CSRC archive data and metadata from the growing California Real Time Network (CRTN). CRTN is a test bed for natural hazards early warning systems (geological and atmospheric), and a platform for real-time positioning and navigation. GPS 1 Hz data flow to a central server with a latency of less than 1 s. This year we added several more stations in Los Angeles and Riverside Counties, including new continuous GPS stations of Earthscope's Plate Boundary Observatory (PBO). The continuous GPS stations make up the backbone of the CSRS. The CRTN stations allow us to monitor crustal motions and react to significant seismic events in virtually real-time. A proposal for statewide California Real Time Network (CRTN – Figure 2) was published and circulated, a series of meetings at Scripps with key players (UNAVCO/PBO, Caltrans, and JPL) was held, and a proposal to California surveying organizations was circulated. Two successful RTN workshops with CLSA in May 2008 (South Region: Ontario, North Region: San Jose) were also held.

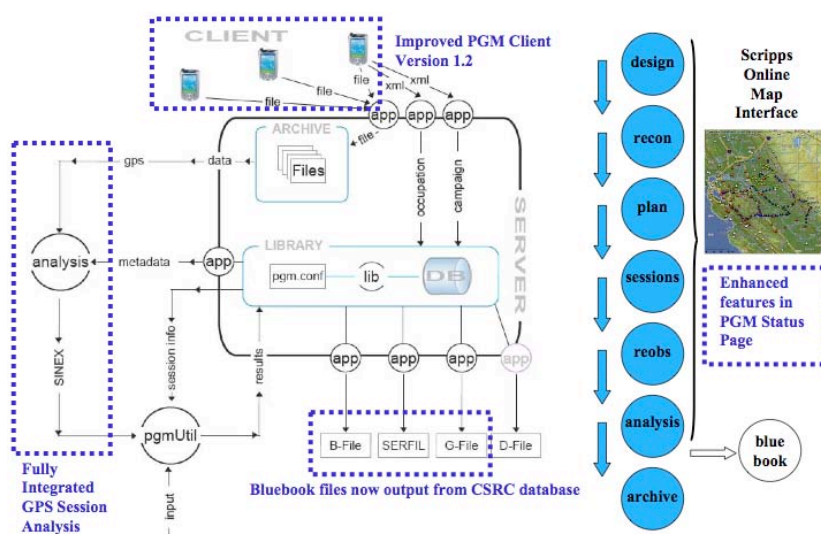


Fig. 1 Schematic of PGM software developed by the CSRC for NGS. The software is used for planning, managing, surveying, analyzing, and archiving height modernization, other geodetic control projects, and crustal deformation surveys. PGM includes client-side and server-side software fully integrated with the SOPAC/CSRC database and data portal, and an analysis component using Geodetics RTD software. Output functions include NGS bluebook files: B-file, G-file and SERFIL

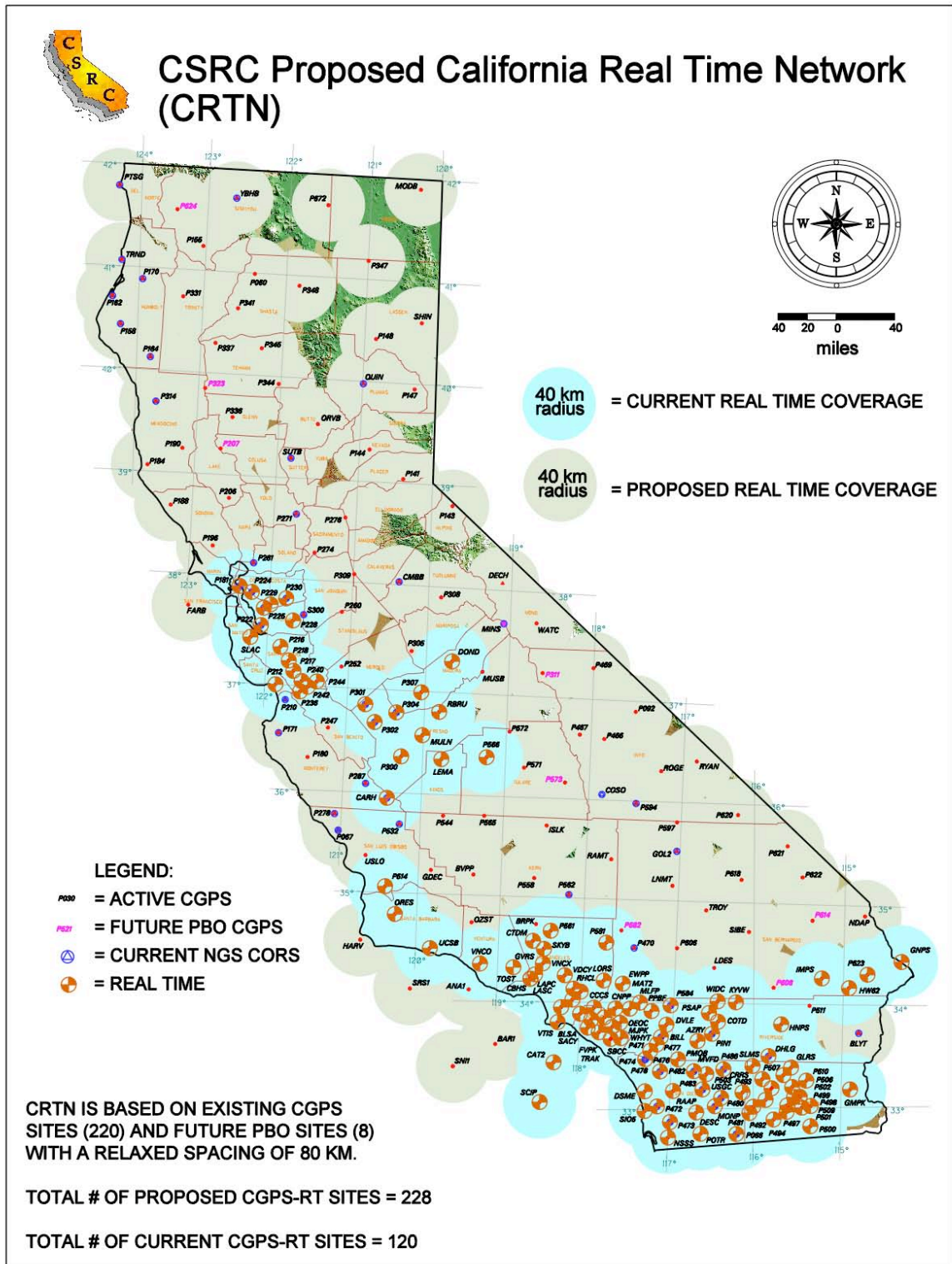


Fig. 2 Proposed Statewide Expansion of the California Real Time Network (CRTN). CRTN is currently operational in southern California. It is a test bed for natural hazards early warning systems (geological and atmospheric), and a platform for real-time positioning and navigation. GPS 1 Hz data flow to a central server with a latency of less than 1 s. The proposed expansion builds upon the already constructed Plate Boundary Observatory, part of the EarthScope Project



Implementation of a Real-Time Precipitable Water Capability Using the Global Positioning System

Yehuda Bock and Peng Fang (SIO)

NOAA Technical Contact: Seth Gutman (GSD/ESRL)

Links to NOAA Strategic Plan:

NOAA Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

NOAA Goal 3: Serve Society's Needs for Weather and Water Information

Research Objectives and Specific Plans to Achieve Them

The primary goal of this research is to estimate precise (≤ 1.5 mm RMS) integrated precipitable water (IPW) within 2 hours using multiple sub-networks of continuous GPS receivers distributed over the continental U.S. as a way of supplementing and improving numerical weather prediction models, i.e., short-term weather forecasting. At NOAA's Earth Systems Research Laboratory, a ground-based GPS meteorology system has been implemented, with continued scientific input, oversight and refinement from the Scripps Orbit and Permanent Array Center (SOPAC). One of the breakthroughs in the system is the ability to generate quality-controlled, hourly orbital estimates for the GPS satellites at SOPAC, using a 24-hour sliding window in hourly increments. The precision of the orbits is about 7 cm within the observed session and below 15 cm in the predicted 12-hour segment.

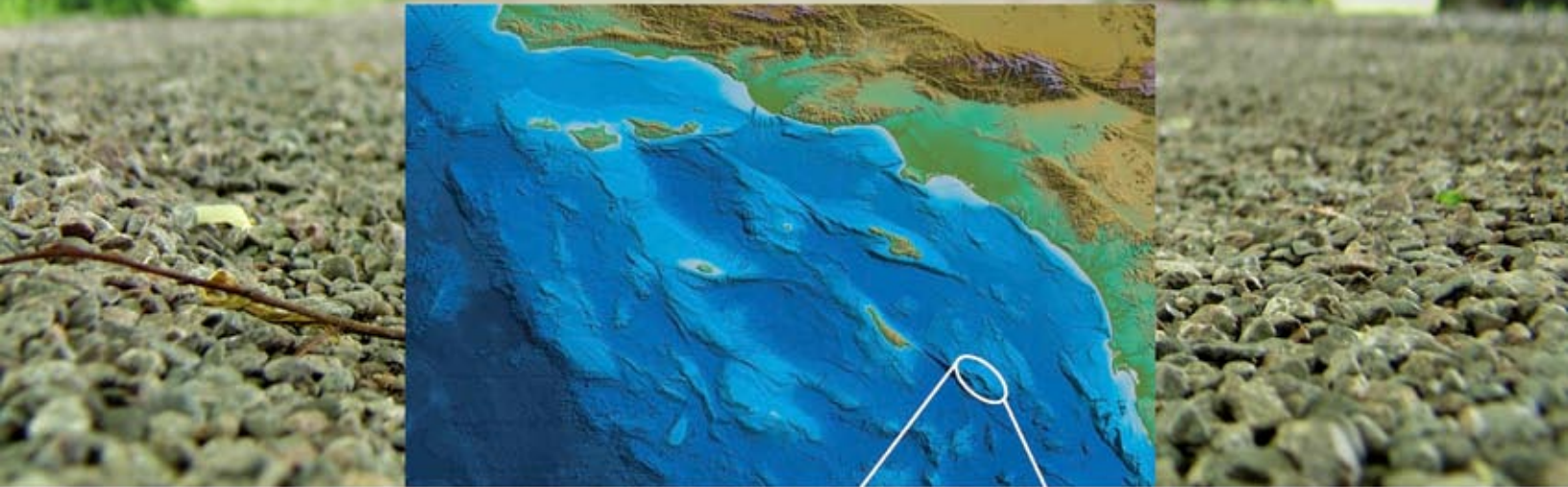
We have evaluated approaches to provide more robust and timely GPS satellite orbits. These include realizing the latest global reference frame, incorporating the absolute antenna phase center model, applying improved tidal loading model and differential code bias correction, introducing more evenly spatial coverage of data from global GPS tracking stations, and developing redundant and more robust quality control mechanisms. We have also evaluated new methodologies to reduce the latency of derived GPS zenith delays from single-epoch instantaneously estimated zenith delay parameters.

The Co-PI (Peng Fang) interacted closely with our sponsor at NOAA (Seth Gutman and his staff) to enhance their system for GPS Meteorology. In addition, he computed numerous special solutions, both northern America and global, on request.

Research Accomplishments

High quality orbits are now delivered hourly with better than 98.6% (5 interruptions over a 365 day period, most of them due to internal or external internet or centralized archive system related problems) reliability with a precision of about 7 cm, and a predictive capability of 15 cm. A redundant processing system has been implemented to improve the reliability of GPS orbit support at SOPAC for NOAA. ITRF2005, a new global reference frame, has been realized. Improved error modeling schemes are incorporated into the data processing system.

This research contributes to atmospheric sounding research in general, directly contributes to operational weather forecasting by NOAA in the U.S. Techniques developed for this system can support other applications in geodynamics and navigation.





OUTREACH

Greater San Diego Science and Engineering Fair

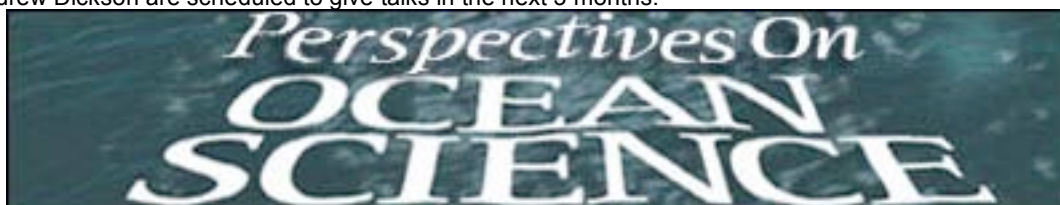
Four graduate students from the Scripps Institution of Oceanography (SIO) represented JIMO as a 'Professional Societies' judging team at the 2008 Greater San Diego Science and Engineering Fair (GSDSEF, www.gsdsef.org). The goal of the GSDSEF is to maintain a continuous process that encourages and rewards professional excellence, promotes educational enrichment, and provides unique opportunities for independent achievement in science and technology for the thousands of seventh through twelfth grade students of all private, parochial, and public schools of the Greater San Diego Region.



The JIMO judging team attended the event in April 2008 and evaluated a subset of the 833 student projects to identify and recognize meritorious efforts that relate to the research programs and projects of SIO and JIMO (oceans, atmosphere, climate, etc.). Winning projects (1st, 2nd, 3rd) were selected from each of the two age groups (Junior and Senior) to receive recognition as outstanding. The senior project selected for 1st place by the JIMO judging team was also selected as one of the top four finishers for the entire event, and advanced to the Intel International Science and Engineering Fair. The project, titled "Further Investigation of Diatoms as Biological Indicators of Pharmaceutical Runoff", successfully tested algae as indicators of the presence of drugs in seawater. The project featured the work of Ronit Abramson, a 16-year-old student intern who was based at a laboratory at SIO.

Perspectives on Ocean Sciences Lecture Series: http://www.aquarium.ucsd.edu/public/persp_online.cfm

The Birch Aquarium at Scripps Perspectives on Ocean Science lecture series is a monthly event designed to inform the general public about research activities at SIO. Researchers create engaging, accessible presentations that typically draw more than 100 guests. Each lecture is filmed and edited by UCSD-TV for broadcast via UCSD-TV, UC-TV and their cable affiliates nationwide (a potential audience of more than 14 million viewers). Archived lectures are streamed from then UCSD-TV and Birch Aquarium web sites as well as from Google video, greatly extending the impact and life of any lecture. Each presentation is digitized and can be viewed online via the UCSD-TV and Birch websites. To date, 9 JIMO fellows (D. Cayan, J. Hildebrand, J. Jackson, J. Orcutt, D. Rudnick, L. Levin, R. Guza, E. Terrill, M. Ohman) have made presentations in this highly successful and far-reaching program. Most recently V. Ramanathan highlighted his work in a presentation titled Atmospheric Brown Cloud: A Double Threat for Asia. Lisa Levin and Andrew Dickson are scheduled to give talks in the next 3 months.



SCOPE

SCOPE, Scripps Community Outreach and Public Education, is an organization of graduate students, faculty and staff at SIO who have come together to identify, as well as create, Education and Outreach (E&O) opportunities for SCOPE members. Students working in JIMO funded labs have participated in a variety of SCOPE sponsored outreach activities including helping with K-12 curriculum review, staff briefings and assistance with program planning with many science education organizations external to SIO.



SCCOOS (PIs: J. Orcutt, R. Davis, E. Terrill) Education and Outreach program

SCCOOS has again partnered with the Center for Ocean Sciences Education Excellence California (5 year renewal) to create educational products for use in middle school classrooms. The partnership includes almost all of the middle schools in the San Diego Unified School District (2nd largest in California) through a program called Enhancing Science Education Through Technology (ESETT). This new COSEE CA initiative is just getting underway, but it is anticipated that SCCOOS programmers will work with Scripps science educators and teachers to create a SCCOOS interface that can readily be used by teachers and students.

Boy Scouts of America – Archaeology Merit Badge

CSTAR member C. Boone assisted a local boy scout in earning a merit badge in archaeology.

Classroom Presentations

P. Adams gave classroom presentations in fisheries studies given at Westlake Elementary School, Holy Cross Elementary School, Santa Cruz, California.

Diversity Outreach

L. Levin gave a guest lecture on methane seeps and oxygen minimum zones at Howard University, Washington, DC in February 2008.

Elementary School Presentations on Ocean Sciences

J. Jackson and members of his project conducted education and outreach efforts as part of the Ocean Sciences curriculum at Rancho Santa Fe Elementary School (San Diego County). L. Levin gave seminars at the same school on deep-sea environments.

High School Presentations on Marine Mammal Sounds

M. McKenna gave a presentation on marine mammal sounds to a class at Hilltop High School in Chula Vista, CA.

High School Teacher Education on Geochemical Cycles

A. Dickson gave presentation to local San Diego high school teachers on geochemical cycles.

K-12 Education

L. Levin was advised on an Earth Science class at Loma Linda Academy.

Laboratory Tours

P. Adams provided a tour of his UC Santa Cruz Fisheries Studies Laboratory for Girls Scout troop.

Lectures to after-school and summer education students at Peabody Museum, Yale University

CSTAR member S. Alonzo participated in the 'Evolutions' after-school and 'Expeditions' summer education outreach program at the Yale Peabody Museum by presenting CSTAR research to students in a lecture series. 'Evolutions' is an after-school program for middle and high schools student from the New Haven public school district and targets students from groups traditionally under-represented in science and engineering.



Participation in Ocean Week 2007

Presentation of J. Jackson's research on Florida Keys historical ecology to Rancho Santa Fe (San Diego, CA) Elementary School students.

Salmon Biology and Conservation Outreach

The Salmon Biology group at UC Santa Cruz gave numerous classroom presentations on Salmon biology and the importance of conservation to Westlake and Holy Cross Elementary Schools (Santa Cruz, CA), as well as a tour of the group's research lab to a local Girl Scout Troop.

COMMUNICATIONS, NETWORKING, ACADEMIC DEVELOPMENT and AWARDS

ACTIVITY TYPE	OBJECTIVE	PARTNERS
Communications		
Argo Science Team web site: http://www-argo.ucsd.edu	Provide information on the Argo project, its objectives, status and data system, including how to access Argo data	International Argo partnership
Argonautics Newsletter http://www.argo.ucsd.edu/Fnewsletter.html	Distribute information on Argo status, applications, and progress on key issues	International Argo partnership
http://cetus.ucsd.edu/	www.cetus.ucsd.edu web site on marine mammal sounds and J. Hildebrand project work	
http://cordc.ucsd.edu/projects/mapping/	Provide online access to surface current mapping sites, radial data, and diagnostics for participating sites	
CSRC web site: http://csrc.ucsd.edu/	Provide on-line access to CSRC resources	
ECPC web site: http://ecpc.ucsd.edu/	Web displays of experimental forecasts and evaluations	USFS, NCEP, IRI, GEWEX, NASA others
High Resolution XBT Network web site: http://www-hrx.ucsd.edu	Describe scope and objectives of the Pacific/Indian HRX network; display data from all cruises; provide downloadable datasets on a cruise-by-cruise basis	CSIRO Australia, NIWA New Zealand, Tohoku University Japan
http://www.ifremer.fr/comarge/en/Gallery_NZvoyage.html	Website coverage of novel OMZ/methane seeps research cruises in New Zealand	Census of Marine Life Comarge
SCCOOS web site: http://www.sccoos.org	To inform stakeholders and the public about SCCOOS governance, observing system components, and education and outreach and to maintain and provide access to data and data products	



SOPAC web site: http://sopac.ucsd.edu/	Provide precise hourly orbits of SOPAC satellites	International GNSS Service (IGS)
Sverdrup Polar Science Program web site: http://spsp.ucsd.edu	Website directed to the general public and research community to increase understanding of the AMLR program and the ecology of the Antarctic	
<i>American Chemistry Council and National Geographic Society Forum</i> , March 2008	Educate the press and CA legislators about research activities	NOAA Marine Debris Program, UC Santa Barbara
CSRC Executive Committee Semi Annual (Fall) Meeting, October 17, 2007 at SIO, La Jolla, CA	Day long business meeting to provide support and advice to the CSRC CSRC	Executive Committee representing surveying community professionals
CSRC Executive Committee Semi Annual (Spring) Meeting, May 7, 2008 at Santa Clara Valley Water District, San Jose, CA	Day long business meeting to provide support and advice to the CSRC CSRC	Executive Committee representing surveying community professionals
CSRC Semi Annual (Fall) Meeting, October 18, 2007 at SIO, La Jolla, CA	Semi-annual business meeting of the CSRC Coordinating Council	UCSD's CSRC Support Group and surveying community professionals
CSRC Semi Annual (Spring) Meeting, May 8, 2008 at Santa Clara Valley Water District, San Jose, CA	Semi-annual business meeting of the CSRC Coordinating Council	UCSD's CSRC Support Group and surveying community professionals
<i>Currents Symposium</i> , Monterey Bay State University, April 2008	Educate the public about research activities and the biology and conservation of salmonids	Monterey Bay National Marine Sanctuary, Monterey Maritime Museum, NOAA Weather Service, NOAA Marine Debris Program, Monterey Bay Salmon and Trout, USGS, UC Santa Barbara
Development and distribution of SCCOOS News	To keep SCCOOS Board, Senior Advisory Committee, PIs, and stakeholders informed of SCCOOS activities and events and ocean and coastal-related news	Distributed to local, regional, state and federal partners, organizations, industry representatives
Development of a fire weather support page for Southern California	Satellite imagery, meteorological data, and models for the October 2007 Southern California fires	
<i>Granite Canyon Laboratory Open House</i> , Monterey, CA, May 2008	Educate 100 regional researchers and Congressman Farr about research activities	UC Santa Barbara, Washington State University, Vancouver
Interview with Richard Harris (National Public Radio) May 7, 2008	To communicate climate change and hypoxia effects to the public	
Journalistic coverage of deep-sea cruises	Communicate Biodiversity issues to public	J. Leake, London Sunday Times, May 2008
Maintenance of mail listservers for CSRC Executive Committee, CSRC Council, and general CSRC membership	Provide a convenient and recordable communications mechanism	
Media coverage: KPBS/NPR and http://www.postcarboncities.net	Communicate and interpret climate science and it's effects on water and energy use in the region to the general public	



Media releases and articles in SIO e-journal on key CalCOFI-based research results	Three media releases and two articles in the SIO e-journal to highlight papers in Nature and the Proceedings of the National Academy of Sciences and publication of a new book by the CalCOFI Director. Media releases taken up widely, leading to articles in newspapers, radio interviews	CalCOFI, SIO
Monthly CSRC Executive Committee Teleconference	Business meeting to provide support and advice to the CSRC	CSRC Executive Committee representing surveying community professionals
Monthly NGS National Height Modernization Teleconference	National Height Modernization Program updates	NGS and representatives of regional height modernization programs
Numerous interactions with California press on a routine basis, by Redmond, Dettinger, Westerling, Cayan and other CAP scientists	To explain elements of climate variability and change	
"Our Changing Climate, Assessing the Risks to California," A Summary Report from the California Climate Change Center. California Energy Commission document, CEC-500-2006-077, by Luers, A.L., Cayan, D.R., Franco, G., Hanemann, M., and B. Croes, and others	To inform Californians about risks of possible climate change	State of California (several state agencies), Union of Concerned Scientists, numerous university and government scientists
Phytoplankton Studies Report	Project report included with the entire AMLR program field season report	NOAA/NWFSC/AERD
Radiowave Operators Working Group (ROWG) information exchange	Updates to real-time coastal data obtained by HF Radar observations disseminated to the Radiowave Operators Working Group	
REEF (Reef Environmental Education Foundation) Meeting, San Francisco, CA	Provide information to diving community on rockfish research	Public
Television coverage of manifestation of low oxygen in marine environments	To communicate to the public how low oxygen environments are created and their effects on marine ecosystems	Fox Channel, June 17, 2008
UCSC Seymour Marine Discovery Center Docent Orientation Tour, March 2008	Inform volunteer docents about research conducted at the laboratory	UCSC Seymour Marine Discovery Center
"Water Year 2006 – Another 'Compressed' Spring in the Western United States", by Dettinger, Cayan, et al. In Mountain Views, the Newsletter of the Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT).	To inform the public of the latest developments regarding the evolution of western climate, and the evolving natural and societal impacts associated with those changes.	Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT)
"Western Ground Water and Climate Change - Pivotal to Supply Sustainability or Vulnerable in Its Own Right", by Dettinger and Earman, in Ground Water News and Views	Advance ground water science, technology and policy	Association of Ground Water Scientists and Engineers



ACTIVITY TYPE	OBJECTIVE	PARTNERS
Networking		
American Congress on Surveying and Mapping, March 4-7, 2008, Spokane, WA	Outreach effort through CSRC exhibit booth	Surveying and mapping professionals
Argo Marine Atlas project ftp://kakapo.ucsd.edu/pub/argo/Pacific Marine Atlas	Develop a data display tool to allow non-expert computer users to view Argo and other ocean datasets as maps, vertical sections, time-series plots, and line drawing	PI-GOOS, SEREAD
Cal Poly Pomona, February 5, 2008, Pomona, CA	Outreach effort	Survey/engineering students
CalGIS Conference, April 23-25, 2008, Modesto, CA	Outreach effort through CSRC exhibit booth	GIS professionals
Caltrans/CSRC Real Time Network Meeting, June 20, 2008 at SIO, La Jolla, CA	Collaboration meeting	County and state partners
Central Coast California Land Surveyors Association (CLSA) Meeting, October 11, 2007	Presentation of updates on CSRC, California Real Time Network (CRTN), and height modernization projects	Surveying professionals
Central Coast Height Modernization Project Pocket GPS Manager Training, September 7, 2007 at SIO, La Jolla, CA	Collaboration meeting	Towill (subcontractor)
Climate forecasts for improving management of energy and hydropower resources in the western U.S.	Build working partnerships with selected partners to demonstrate seasonal forecast applications	California Department of Water Resources
Correspondence with Judd Muskat, OSPR	Discussed ingestion of HF Radar data in ArcGIS via shapefile format	Office of Spill Prevention and Response
Correspondence with Glen Watabayashi, NOAA HAZMAT	Discussed ingestion of HF Radar data into GNOME model via NetCDF format	NOAA HAZMAT
County Engineers Association of California (CEAC) Meeting, November 14, 2007, Oakland, California	Regional partnership meeting	Surveying and engineering professionals
County Engineers Association Meeting (CEAC) Meeting, March 5, 2008, La Jolla, CA	Regional partnership meeting	Surveying and engineering professionals
CSRC/PBO Meeting, April 9, 2008 at SIO, La Jolla, CA	Collaboration meeting	UNAVCO PBO, county, and state partners
Develop collaborative research with colleagues in Baja California	Develop collaborative program with colleagues in Baja California, Mexico to examine the dynamics of spiny lobster	Armando Vega, Guillermo Ortuno, Centro Regional de Investigacion Pesquera (CRIP), Instituto Nacional de la Pesca, Ensenada/La Paz, Mexico
	Contribute to planning of California MPAs	Workshops on MPA planning process



Developing cross-RISA activity involving climate change and management of the Colorado River	Improve access to climate monitoring information, relating to natural resource management in the western states, and with NOAA and Climate Testbed to improve linkages between climate forecasts and regional applications, and to improve institutional linkages to universities by Redmond and other CAP scientists	
Fresno Geomatics Conference, California State University, January 24-26, 2008, Fresno, CA	Outreach effort through CSRC exhibit booth	Geomatics professionals
GEWEX	Provide and evaluate reanalyses of water and energy variables	NASA, NOAA
HABs Working Group kick-off meeting, 15 October 2007	Begin development of HABs surveillance program	Stephanie Peck, Burt Jones, Dave Caron, other members
Hosted visitor from Spain (Spanish representative of CODAR Ocean Sensors)	Hosted Javier Garcia Parra, of Qualitas Instruments providing guidance and experience with HF Radar electronics and processing	Qualitas Instruments
International Collaboration within AMLR	Increase the breadth of JIMO Phytoplankton research in the Antarctic	José Luis Iriarte (Universidad Austral de Chile, Puerto Montt, Chile), Nelson Silva (Escuela de Ciencias del Mar, Universidad Católica de Valparaíso, Valparaíso, Chile), Murat Ardelan (Biological Station, Trondheim, Norway), Kemal Can Bizsel (Institute of Marine Sciences & Technology, Dokuz Eylül University, Turkey)
League of California Surveying Organizations (LCSO) Meeting, October 4, 2007 Port of Long Beach, CA	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) Meeting, November 1, 2007 County of Riverside, CA	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) Meeting (hosted by CSRC), December 6, 2007, SIO, La Jolla	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) Meeting, January 10, 2008, Los Angeles County, CA	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) Meeting, February 7, 2008, RBF Consulting, Irvine, CA	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) Meeting, March 13, 2008, County of Ventura, CA	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) State of NGS Meeting, April 3, 2008, Riverside, CA	Regional partnership meeting	NGS and surveying professionals
League of California Surveying Organizations (LCSO) Meeting, May 1, 2008, County of Orange, CA	Regional partnership meeting	Surveying professionals



League of California Surveying Organizations (LCSO) Meeting, June 5, 2008, San Bernardino, CA	Regional partnership meeting	Surveying professionals
League of California Surveying Organizations (LCSO) Meeting, July 10, 2008, Long Beach, CA	Regional partnership meeting and presentation of the CRTN Statewide Proposal	Surveying professionals
Meeting with Luke Nachbar, NOAA Legislative Affairs, June 13, 2008 at SIO, La Jolla, CA	Outreach effort	NOAA
Meeting with regional lifeguard agencies representatives, 10 September 2007, La Jolla, CA	Conduct targeted marine safety outreach; discuss data product needs	SCCOOS: Stephanie Peck; Michael Bateman; Cities of Encinitas, Del Mar, San Diego, Coronado
Multinational cruises: <i>R/V Tangaraoa</i> (New Zealand), <i>R/V Sonne</i> (Germany), <i>R/V Atlantis</i> (USA), <i>R/V Vidal Gormaz</i> (Chile)	Multidisciplinary collaboration and sharing of resources	NIWA, New Zealand Univ. Católica Norte, Chile GEOMAR, Germany
NFRA Board Meeting, 2 March 2008, Orlando, FL	Meeting of Board members and representatives of Regional Associations; meet with IOOS Director and staff	Stephanie Peck
NGS Convocation/Height Modernization Partners Meeting, February 20-22, 2008, Virginia Beach, VA	Meeting with NGS and regional/state height modernization partners	NGS and representatives of regional height modernization programs
NGS Height Modernization Meeting, September 5 and 6, 2007, Silver Springs, Maryland	Meeting with NGS and regional/state height modernization partners	NGS and representatives of regional height modernization programs
NGS Height Modernization Meeting, October 26, 2007, Chicago, Illinois	Meeting with NGS and regional/state height modernization partners	NGS and representatives of regional height modernization programs
NGS HT Mod Partnership Meeting, November 16, 2007, Washington DC	Meeting with Admiral Lautenbacher	NOAA
NGS Real Time Network Operators Meeting, May 16, 2008, Sacramento, CA	Regional partnership meeting	NGS, Caltrans, and private industry
NOAA/IOOS Regional Association Assessment, 4 June 2008, Seattle, WA	NOAA to conduct briefings and reviews Regional Associations of SCCOOS, CeNCOOS, NANOOS	NOAA IOOS (Zdenka Willis, Timi Vann), NOAA (Geno Olmi, Becky Smythe), SCCOOS (Eric Terrill, Stephanie Peck), CeNCOOS (Steve Ramp, Heather Kerker), NANOOS (David Martin, Jan Newton), AOOS (Molly McCammon), PaCOOS (Jonathan Phinney), LMI
North Island Weather Service (METOC) visit with CDIP and SCCOOS, 13 November 2007	Provide SCCOOS and CDIP presentation; explore collaboration opportunities	SCCOOS, METOC representatives
Northern California GPS Users Meeting, Contra Costa County Offices, December 14, 2007, Martinez, CA	Regional partnership meeting and provided an update on CSRC, CRTN, height modernization projects; epoch methods; deformation monitoring with CGPS	Surveying professionals
Ocean U.S./Regional Association monthly conference calls (ongoing)	Information exchange and updates on development of Regional Associations and regional ocean observing systems	SCCOOS staff, Regional Associations, NFRA, NOAA CSC, Ocean.US



Orange County Coastal Coalition - attendance by Stephanie Peck at monthly meetings (ongoing)	Keep abreast of coastal and ocean observing related issues in Orange County	Representatives of Orange County Board of Supervisors, Orange County Sanitation District, County of Orange Health Care Agency, CalCoast
Pacific Island Global Ocean Observing System (PI-GOOS) Advisory Committee	Assist Pacific island nations in gaining benefit from global ocean observations and products	South Pacific Applied Geosciences Commission (SOPAC), NOAA, BoM Australia, NIWA New Zealand, Intergovernmental Oceanographic Commission, South Pacific nations
Radiowave Operators Working Group (ROWG) Meeting presentation, 10-17 September 2007	Workshop held to garner input from participants into a "Best Practices" document highlighting the many aspects of HF radar operations including siting requirements, communications, supporting equipment, software settings, data management, and quality assurance/quality control. The workshop was supported through IOOS as part of an effort to bring the HF Radar technical community together for discussions on field installations, radar operation, software programming, and site integration	Representatives from SCCOOS Radiowave Operators Working Group, HF radar technical community representatives, IOOS, Rutgers University
Riverside/San Bernardino CLSA Meeting, November 29, 2007	Regional partnership meeting	Surveying professionals
SANDAG Shoreline Preservation Committee - attendance by Julie Thomas at monthly meetings (ongoing)	Stay apprised of and participate in discussion of coastal and beach issues affecting San Diego county coastline	Representatives of City and County of San Diego, coastal cities in San Diego County, and other coastal organizations.
Santa Clara Valley Water District Meeting, October 16, 2007, San Jose, CA	Regional partnership meeting	Surveying professionals
SCCOOS Board of Governors Meeting, 9 June 2008, Costa Mesa, CA	Conduct meeting of SCCOOS governing board; provide updates of SCCOOS operations and activities, and state and federal related activities; review SCCOOS progress; discuss SCCOOS direction.	John Orcutt, SIO; Tim Baumgartner, CICESE; Donal Manahan, USC; Jim McWilliams, UCLA; David Tralli, JPL; Soroosh Sorooshian, UC Irvine; Libe Washburn, UCSB; Steve Weisberg, SCCWRP; Matthew Arrott, UCSD; Mark Brzezinski, UCSB; Yi Chao, JPL; Bob Guza, UCSD; Ben Holt, JPL; Burt Jones, USC; Carolyn Keen, UCSD; Dan Rudnick, UCSD; Eric Terrill, UCSD; Julie Thomas, UCSD
SCCOOS booth and presentation to California Surf Lifesaving Association, 14 April 2008	Present SCCOOS activities and data products to lifeguard and safety agencies	Michael Bateman
SCCOOS meeting with OSPR, 8 February 2008, La Jolla, CA	Begin discussions of SCCOOS support of NPREP oil spill simulation drill	Stephanie Peck, Robin Lewis
SCCOOS participates in meeting on HF Radar use for oil spill response, 17 January 2008, Oakland, CA	Discuss technical response to monitoring the COSCO BUSON oil spill and the use of ocean observation data to improve the timing and accuracy of oil spill response efforts	Eric Terrill, State Coastal Conservancy's Ocean Science Applications, NOAA, IOOS, NOAA's Office of Response and Restoration (OR&R), CeNCOOS



SCCOOS participates in Southern California Bight '08 Regional Monitoring Program meeting, 19 September 2007, Costa Mesa	Identify interested organizations and develop a set of preliminary monitoring questions within the areas of coastal ecology, offshore water quality, beach water quality, areas of special biological significance, rocky habitat, and wetlands.	Stephanie Peck, SCCWRP staff, representatives of local and regional water quality, sanitation districts, municipal agencies, environmental organizations
SCCOOS participates in the Southern California Bight '08 Regional Monitoring Program meeting, 28 January 2008, Costa Mesa, CA	Discuss the study design questions, sampling approaches, and level of effort for the water quality element of the Bight '08 Regional Monitoring Program	Stephanie Peck, SCCWRP staff, representatives of local and regional water quality, sanitation districts, municipal agencies, environmental organizations
SCCOOS presentation to San Diego ALERT, 11 October 2007, Encinitas, CA	Inform representatives of SCCOOS observation activities and data products	Stephanie Peck, representatives of lifeguard agencies, harbor safety, CA Parks, and San Diego coastal cities
SCCOOS presentation to San Diego Area Contingency Planning committee, 7 March 2008, Carlsbad, CA	Presentation of SCCOOS observational and monitoring system; discuss SCCOOS role in June NPREP exercise	Stephanie Peck, Mark Otero
Ventura College GIS Day Meeting, November 16, 2007	Outreach effort	GIS students
UNAVCO/PBO/JPL/SIO Meeting, July 18, 2008 at SIO, La Jolla, CA	Collaboration meeting	UNAVCO PBO and JPL
US fire danger forecasts	Participate in US wide discussions of upcoming fire danger	NICC, GACCs, USFS
US Navy Rear Admiral Gove visits SIO; SCCOOS presentation provided, October 2007, La Jolla, CA	Rear Admiral David Gove, Oceanographer & Navigator of the Navy, was briefed on SCCOOS, Coastal Data Information Program (CDIP), and the development of the national IOOS. SCCOOS and CDIP staff briefed Admiral Gove on coastal observing applications for assessment of ecosystem trends, long-term climate change trends, military use, oil spill response, regional ocean modeling, search and rescue, storm water discharges and outfall tracking, vessel traffic aids, and water quality. The briefing included an overview of SCCOOS structure, participants, assets and activities, highlighting HR Radar surface current mapping array, long-term historical time series, glider operations, water quality and trajectory mapping applications.	Eric Terrill, Lisa Hazard, Julie Thomas



ACTIVITY TYPE	OBJECTIVE	PARTNERS
Academic Development		
At-sea training for undergraduate students	CalCOFI cruises provide opportunities for students to participate in at-sea research aboard a vessel	
Book review: Deep-sea Biodiversity	Review manuscript for Harvard University Press	Harvard Univ. Press
Fellowships Programs / Internships in deep-sea research	Undergraduate involvement (C. Rochman and S. Chow) in deep-sea research cruises and sample analyses via research for credit or internships	NSF REU Program UCSD Faculty mentor program
	C. Boone trained three interns in ichthyofaunal analysis techniques, one of whom presented a paper on prehistoric fish processing in Elkhorn Slough at the 35th Annual Western Departments of Anthropology and Sociology Undergraduate Research Conference, Santa Clara University, April 5th, 2008	UC Santa Cruz
Graduate student development	Foster participation of graduate students in climate research	University of Washington, Engineering Dept. (E. Rosenberg)
Graduate student development	Analysis and publication of the DYCOMS-II measurements was used to train a graduate student and to further her progress towards a doctoral degree. Training on the Scripps Pier Aerosol Mass Spectrometer will provide experience working with instruments in the field in preparation for VOCALS. In addition, the student presented the current results of TEXAQS measurements at the Global Emissions Inventory Activity meeting in France in September 2007	NOAA/PMEL (P. Quinn and T. Bates)
JIMO post-doctoral fellowship program	A JIMO post-doctoral fellowship program was advertised and was awarded to Ana Lara Lopez who will work in the area of climate and higher trophic levels, leveraged on the CalCOFI program and Sung Hyun Nam who will work in the area of remote sensing with U. Send and E. Terrill	Recruited internationally
NSF Panel	Review of the Ridge Program (L. Levin)	NSF



Published paper on influence of Multiple Signal Classification (MUSIC) algorithm	Provided guidance to members of HF Radar community regarding influence of beam patterns on radial data	HF Radar Community
Scripps/UCSD PhDs [mentored by J. Roads, and others]	3 Ph.D. theses completed 2 Ph.D. theses begun	NASA, NOAA
Scientific Committee on Oceanic Research (SCOR) working group on hypoxia	L. Levin (member) attending group meeting in Shanghai, China	SCOR—International partners
SERREAD program	Develop curricular units and conduct teacher-training seminars for teaching of weather, climate, sea level, and the ocean's role in climate in Pacific island school systems. See http://www.argo.ucsd.edu/FrEducational_use.html	SOPAC, UNESCO, NOAA, NIWA/NZ, IOC, Education ministries in Cook Is, Samoa, and Fiji
Mentoring of undergraduate students	D. Swank (UCSC) mentored Jaisy Hanson, a third-year student in the Dept. of Environmental Studies. Her project was on back-calculating length at age of juvenile steelhead using scale analysis	UC Santa Cruz
	E. Dick helped in mentoring of 2 M.S. degree students at Moss Landing Marine Laboratories	Moss Landing Marine Laboratories
Undergraduate internships:		
2 students at SIO for euphasiids data enumeration project (M. Ohman)	Taxonomic training of undergraduate students	UC Santa Cruz
3 students at UC Santa Cruz for Salmon Studies project (P. Adams)	Research experience in fisheries studies as part of the Adams Lab	UC Santa Cruz
3 students at UC Santa Cruz for Shipboard Studies (B. Marinovic)	Research experience in fisheries research as part of the Marinovic Lab	UC Santa Cruz
Undergraduate Student training (Foreign Students: Maria Jose Calderón Nash (Universidad Austral de Chile, Valdivia, Chile), Nitza Vera Santana Viviana, and Cristina Carrasco (Escuela de Ciencias del Mar, Universidad Católica de Valparaíso, Valparaíso, Chile) participated on AMLR Cruise 2008	To educate and encourage environmental ecology of the Southern Ocean for Chilean undergraduates to further their studies	José Luis Iriarte, Universidad Austral de Chile, Puerto Montt, Chile and Nelson Silva, Escuela de Ciencias del Mar, Universidad Católica de Valparaíso, Valparaíso, Chile



AWARD	RECIPIENT	YEAR
Awards and Honors		
American Meteorological Society (AMS) Sverdrup Gold Medal Award	D. Roemmich (SIO)	2008
Department of Commerce Bronze Medal for work on Essential Fish Habitat	M. Yoklavich and others (UCSC)	2007
Distinguished lecturer, Rutgers Institute of Marine Science	G. Sugihara (SIO)	2008
Fellowship, Women Evolving Biological Science	Y. Lucero (UCSC)	2008
Graduate Student Travel Award to the Meeting of the Society for Industrial and Applied Mathematics	C. Simon (UCSC)	2008
Gulf and Caribbean Fisheries Institute Outstanding Presentation Award	L. McClenachan (SIO)	2007
JIMAR Visiting Scholar, University of Hawaii	M. Mangel (UCSC)	2008
McQuown Chair in Natural Science at Scripps Oceanography	G. Sugihara (SIO)	2007
NMFS Best Scientific Paper Award, Fishery Bulletin	M. Yoklavich and T. Anderson (UCSC)	2008
NRC Postdoctoral Fellowship	Y. Lucero (UCSC)	2007-08
Riley Lectures, Dalhousie University	L. Levin (SIO)	2008
Roger Tory Peterson Medal of the Harvard Museum of Natural History	J. Jackson (SIO)	2007
Scholarship for 2008 International graduate training course in Antarctic biology, Jan 5th to Feb 5th 2008 "Integrative biology and adaptation of Antarctic marine organisms"	K. Cresswell (UCSC)	2008
Sherman Eureka Prize for Environmental Research Finalist (Australia)	J.A. Koslow (SIO)	2007
Travel award to the Industrial Mathematical & Statistical Modeling Workshop for Graduate Students, July 21-29, 2008, Center for Research in	L. Robledo (UCSC)	2008



Scientific Computation, Raleigh, NC

Victoria Premier's Award for Scientific Writing for the book <i>The Silent Deep</i>	J.A. Koslow (SIO)	2007
William V. Kaeser Visiting Scholar University of Wisconsin	M. Mangel (UCSC)	2008
The Zayed International Prize for the Environment	V. Ramanathan (SIO)	2008







REPRESENTING JIMO

EVENT	DATE / LOCATION	REPRESENTATIVE
1 st CLIVAR Global Synthesis and Observation Panel Workshop on Ocean Velocity Measurements and their Application: "Drifter Technology and Surface Circulation"	5-7 Dec 2007 / La Jolla, CA	P. Niiler
5 th Annual Climate Prediction Applications Science Workshop	20-23 Mar 2008 / Seattle, WA	E. Rosenberg, A. Wood, Q. Tang, A. Steinemann, B. Imam, S. Sorooshian, D. Lettenmaier
7 th Symposium on Fire & Forest Meteorology	22-26 Oct 2007 / Bar Harbor, ME	J. Roads
11 th International Symposium on Biological and Environmental Reference Materials (BERM-11)	29 Oct – 2 Nov 2007 / Tsukuba, Japan	A. Dickson
13 th FIG International Symposium on Deformation Measurements and Analysis	12-15 May 2008 / Lisbon, Portugal	C. Whitaker
15 th Western Groundfish Conference	Feb 2008 / Santa Cruz, CA	T. Laidig, M. Yoklavich, D. Watters
26 th Annual Salmon Restoration Conference	5-8 Mar 2008 / Lodi, CA	E. Mora
2007 State of Estuary Conference Talk	Oct 2007 / Oakland, CA	D. Cayan
ACWA Documentary Interview	Oct 2007 / La Jolla, CA	D. Cayan
American Association for the Advancement of Science	Feb 2008 / Boston, MA	L. McClenachan
America Association of Aerosol Research Annual Meeting: "Comparison of Organic Functional Groups from FTIR and Organic Mass Fragments from AMS at Six North American Field Studies" and "Organic functional groups and trace metals in submicron aerosol by FTIR and XRF in the Gulf of Mexico during TEXAQS/GoMACCS 2006"	27 Sep 2007 / Reno, NV	L.M. Russell, S. Gilardoni, L. N. Hawkins, T. S. Bates, J. D. Allan, D. Baumgardner, P. F. DeCarlo, E. Dunlea, J. L. Jimenez, T. B. Onasch, D. R. Worsnop
American Chemistry Council/Nat'l Geographic Forum	May 2008 / Sacramento, CA	D. Watters
American Fisheries Society Annual Meeting	2-6 Sept 2007 / San Francisco, CA	S. Carlson, W. Satterthwaite, D. Swank, D. Boughton, M. Jessop, E. Mora, K. Pipal, T. Williams,
American Fisheries Society California-Nevada chapter meeting	3-5 Apr 2008 / Lake Tahoe, CA	M. Jessop, K. Pipal, D. Rundio
American Fisheries Society Western Division meeting	4-9 May 2008 / Portland, OR	T. Williams
American Geophysical Union (AGU) Fall Meeting: "Effects of Organic Particle Types and Mixtures on Aerosol Water" (Russell et al.)	12 Dec 2007 / San Francisco, CA	M. Scanderbeg, A. Hamlet, A. Westerling, T. Barnett, D. Lettenmaier, L.M. Russell, S. Takahama, S. Gilardoni, L.N. Hawkins
American Meteorological Society (AMS) Conference on Tropical Meteorology: "Drifting buoy deployments into Hurricane Dean, 2007"	2 May 2008 / Orlando, FL	R. Lumpkin, P. Niller, P. Black
American Water Resources Association	17-19 Mar 2008 / San Mateo, CA	E. Mora
Annual Meeting of the British Ecological Society	7-9 Sep 2008 / Glasgow, UK	M. Mangel
AOGS Meeting	Jul 2007 / Bangkok, Thailand	J. Roads
ARC's Council Meeting	20-22 Oct 2007 / Tallahassee, FL	J. Roads



ASLO/AGU/TOS/ERF Ocean Sciences

Meeting: "Open ocean versus coastal upwelling: consequences for iron and macronutrients in the southern California Current System" (King & Barbeau); "Pelagic ecosystem changes in the North Pacific" (Allan & McGowan); "Effects of High CO₂ on Otolith Growth in a Marine Fish" (Checkley et al.); "Size structure of phytoplankton communities in the California Current" (Goericke et al.); "Effects of High CO₂ on Otolith Growth in a Marine Fish" (Checkley et al.)

2-7 Mar 2008 / Orlando, FL

K. Allan, R. Asch, G. Auad, A. Baco, K. Barbeau, D. Checkley, A. Dickson, N. Eisenkolb, R. Goericke, A.L. King, L. Levin, J.A. McGowan, J. Orcutt, S. Peck, A. Radich, M. Roadman, R. Rykaczewski, M. Takahashi, E. Terrill

Berkeley Atmospheric Sciences Center Seminars: "Organic functional groups and iron oxidation states in atmospheric particles"	12 Feb 2008 / UC Berkeley, Berkeley, CA	L. M. Russell
CalCOFI 2007 Symposium: "The state of the California Current"; "CalCOFI Data Management: Developing Working Standards. Poster Presentation"; "Ocean Informatics Database: A Multi-Project Data Publishing System. Poster Presentation"; "Metadata Standards: Augmenting the Ecological Metadata Language. Poster Presentation"	Nov 2007 / San Diego, CA	R. Goericke and others, K. Baker, J. Wilkinson, R. Charter, M. Kortz, J. Conners, L. Yarmey,
"California Assessment" Talk for SIO Graduate class	Apr 2008 / La Jolla, CA	D. Cayan
California Biodiversity Council	3 Oct 2007 / Clarksburg, CA	S. Lindley
California Energy Commission -- "Climate Change & Energy" (Invited talk)	Apr 2008 / Sacramento, CA	D. Cayan
California Energy Commission PIER Climate Change Conference	Sep 2007 / Sacramento, CA	D. Cayan
California Land Surveyors Association (CSLA) Conference	24-27 Feb 2008 / Reno, NV	C. Whitaker
California Land Surveyors Association (CSLA)/CSRC Real Time Network Workshop	2 May 2008 / Ontario, CA	Y. Bock (Director), G. Helmer (Past Chairperson), S. Martin (CSRC Executive Committee), and C. Whitaker (CSRC Consultant)
California Land Surveyors Association (CSLA)/CSRC Real Time Network Workshop	9 May 2008 / San Jose, CA	J. Canas (CSRC Executive Manager), G. Helmer (Past Chairperson), S. Martin (CSRC Executive Committee), and C. Whitaker (CSRC Consultant)
CEBIC Summer Workshop: "The influence of iron on deep chlorophyll maximum phytoplankton communities in non-HNLC regions"	Jun 2007 / Princeton Univ., NJ	B.M. Hopkinson, K. Barbeau
Central Valley Project (OCAP) Temperature Modeling Tools Workshop	1 Apr 2008 / Sacramento, CA	E. Danner
CEOP Meeting	6-9 Sep 2007 / Bali, Indonesia	J. Roads
Channel Islands Symposium	5-8 Feb 2008 / Ventura, CA	M. McKenna
Climate change effects on San Diego Ecosystem Casa del Prado/Balboa Park: "Likely local climate scenarios" (Invited)	Nov 2007 / San Diego, CA	D. Cayan
Climate Change Law Conference (Invited talk)	Feb 2008 / Los Angeles, CA	D. Cayan
Climate Change Research in CA and Google Earth Conference Call	Jan 2008 / La Jolla, CA	D. Cayan
CLIVAR GSOP	Mar 2008 / Southampton, UK	U. Send
CoMARGE Workshop	Nov 2007 / Auckland, New Zealand	L. Levin



CSO CZM Ocean Observing Workshop	25-26 Sep 2007 / San Francisco, CA	E. Terrill, S. Peck
Data Buoy Cooperation Panel (DBCP) XXIII: "Drifting Instrumented Chains. New Technical Development and Applications" and "Observations of Hurricanes from Air-Deployed Drifters" and "The Global Drifter Program" (P. Niiler et al.)	15-19 Oct 2007 / Jeju Island, Korea	L. Centurioni, P. Niiler, R. Lumpkin, U. Send
Department of Water Resources (DWR) Meeting: Frank Gehrke, Mike Andrews visit	Jun 2008 / La Jolla, CA	D. Cayan
Desert Research Institute Seminars: "Effects of Organic Particle Types and Mixtures on Aerosol Water"	21 Dec 2007 / Reno, NV	L.M. Russell
"Earth Seminar Series" Seminar on Climate Change and Regional Water Resources	Mar 2008 / La Jolla, CA	D. Cayan
Eastern Boundary Upwelling Ecosystem Symposium: "Processes and patterns in the California Current System" (oral, plenary presentation)	Jun 2008 / Las Palmas, Canary Islands	D. Checkley
Eastern Pacific Ocean Conference	Sep 2007 / Leavenworth, WA	C. Edwards
Ecological Society of America	Aug 2007 / San Jose, CA	S. Carlson, M. Fujiwara, W. Satterthwaite, M. Mangel, L. Robledo
Ecosystem Based Management in the California Current	22-23 Jan 2008 / Santa Cruz, CA	M. Mangel
EGU	Apr 2008 / Vienna, Austria	A. Thurber
EMS Meeting	Sep 2007 / San Lorenzo de Escorial, Spain	J. Roads
Focus 2050 Steering Committee Meeting San Diego Foundation	Jan 2008 / San Diego, CA	D. Cayan
Fresno Geomatics Conference	24-26 Jan 2008 / Fresno, CA	C. Whitaker, CSRC Consultant
Global Emissions Inventory Activity Summer School: "Organic functional groups and trace metals in submicron aerosol by FTIR and XRF in the Gulf of Mexico during TEXAQS/GoMACCS 2006"	18 Sep 2007 Ile d'Oleron, France	L.N. Hawkins, L.M. Russell, T.S. Bates
Ground Water Long Range Planning Talk	Feb 2008 / Ontario, CA	D. Cayan
Groundfish Stock Assessment Review Workshop	Dec 2007	E. Dick
Gulf and Caribbean Fisheries Symposium	Nov 2007 / Punta Cana, Dominican Republic	L. McClenachan
H2O Conference	24 Sep 2007 / Redondo Beach, CA	J. Chen
HF Radar Technical Training	24-25 Jun 2008 / University of California, Santa Cruz, CA	M. Otero
HF Radar Technical visit to Codar Ocean Sensors	9 Oct 2007 / Codar Ocean Sensors, Mountain View, CA	T. de Paolo, E. Terrill
HF Radar Technical visit to Codar Ocean Sensors	21-23 Apr 2008 / Codar Ocean Sensors, Mountain View, CA	T. Cook
Howard University Guest Lecture	Feb 2008 / Washington, DC	L. Levin
Hypoxia Workshop	Jun 2008 / Las Palmas, Canary Islands (UNESCO)	L. Levin
ICESM Meeting	27-31 Aug 2007 / Hamburg, Germany	J. Roads
Informal Symposium on Kinetic and Photochemical Processes in the Atmosphere: "Mixtures of Organic Functional Groups in Individual Atmospheric Particles" and "Organic functional groups and trace metals in submicron aerosol by FTIR and XRF in the Gulf of Mexico during TEXAQS/GoMACCS 2006"	20 Feb 2008 / UCLA, Los Angeles, CA	T.S. Bates, L.M. Russell, S. Takahama, L.N. Hawkins, S. Liu, R.E. Schwartz



Integrating Climate and Ecosystem Dynamics Southern Ocean Food Web Modeling	16-18 Apr 2008 / Norfolk, VA	J. Wiedenmann
Integrated Ecosystem Assessment (IEA) Workshop to explore role of Regional Associations in development of IEA for California Current	2-3 Jun 2008 / Portland, OR	E. Parnell (SCCOOS), representatives from CeNCOOS, NANOOS, AOOS, NOAA, and approximately 40 other attendees
Interagency Ecological Program	27-29 Feb 2008 / Asilomar, CA	S. Lindley
International Argo Data Management Team Meeting	Nov 2007 / Hobart, Tasmania	D. Roemmich
International Argo Steering Team Meeting	Mar 2008 / Southampton, England	M. Scanderbeg, J. Gould
International Coral Reef Symposium	Jul 2008 / Fort Lauderdale, FL	J. Jackson, L. McClenachan
International Radiowave Oceanography Workshop (ROW)	28 Apr – 2 May 2008 / University of Hawaii, Honolulu, HI	E. Terrill
International Union of Geodesy and Geophysics General Assembly	Jul 2007 / Perugia, Italy	R. Davis, J. Gould, D. Roemmich, J. Roads
International Workshop on Shipping Noise and Marine Mammals	21-24 Apr 2008 / Hamburg, Germany	M. McKenna
ION GNSS 20th International Technical Meeting of the Satellite Division	25-28 Sep 2007 / Forth Worth, TX	C. Whitaker
IOOS Maritime Domain Awareness Summit	24-26 Sep 2007 / Washington, DC	J. Thomas, Capt. R. McKenna
IOOS Regional Grantees Data Management Workshop	6-7 Feb 2008 / Charleston, SC	J. Bowen, J. Thomas
IOOS and OOI Symposium	5-7 Aug 2007 / SIO, La Jolla, CA	E. Terrill, S. Peck, L. Hazard, C. Keen
IPY-ICEALOT R/V Knorr Seminars: "Mixtures of Organic Functional Groups in Individual Atmospheric Particles"	20 Apr 2008 / on board the NOAA R/V Knorr	L. M. Russell
Keelung National Ocean University invited lecture: "Observing Tropical Cyclones with Drifting Buoys"	20 Mar 2008 / Keelung National Ocean University, Taiwan	R. Lumpkin, P. Niiler
The Living Desert Talk (Invited)	Jan 2008 / Palm Desert, CA	D. Cayan
Local Government's Forum (Invited talk)	Apr 2008 / Oakland, CA	D. Cayan
Lydia Roach Qualifier Exam	Dec 2007 / La Jolla, CA	D. Cayan
Marine Debris Forum	Apr 2008 / Bethesda, MD	M. Yoklavich, D. Watters
Migration - A Synthesis	27-29 Apr 2008 / Imperial College at Silwood Park, London, UK	K. Cresswell, W. Satterthwaite
Modeling Intercomparison Meeting Old Scripps Classroom	Sep 2007 / La Jolla, CA	D. Cayan
Monitoring responses of Pacific salmon to climate change	10-12 Mar 2008 / Santa Barbara, CA	P. Adams
Monterey Bay Currents Symposium	5 Apr 2008 / Monterey, CA	H. Fish, M. Yoklavich, T. Laidig
MTS/IEEE Oceans	1-4 Oct 2007 / Vancouver Convention & Exhibition Center, Vancouver, BC, Canada	T. Cook, T. de Paolo
MVCAC Meeting: "Climate and Mosquito Abundance" (Invited talk)	Jan 2008 / Palm Springs, CA	D. Cayan
Napa Valley Vintners (Invited Talk)	Aug 2007 / St. Helena, CA	D. Cayan
NASA Carbon Cycle and Ecosystems Joint Science Workshop	28 May–2 Jun 2008 / Adelphi, MD	E. Danner
NESDIS Senior Leadership Retreat Talk	Jun 2008 / La Jolla, CA	D. Cayan
NEWS Meeting	19-21 Sep 2007 / Huntsville, Alabama	J. Roads
NOAA Headquarters, briefing	Jul 2007 / Silver Spring, MD	L. McClenachan
NOAA IOOS Region Meeting	23-25 Oct 2007 / St. Petersburg, FL	S. Peck, E. Terrill
NOAA NMFS 10th National Stock Assessment Workshop	May 2008 / Port Townsend, WA	E. Dick
NOAA NMFS seminar series: "Information Management Strategies: Data, Metadata, and Change"	Feb 2008 / NOAA SWFSC, La Jolla, CA	K. Baker



North American Hydr. Climate Workshop	16-20 Oct 2007 / Boulder, CO	J. Roads, M. Kanamitsu
NSF Neon Group VTC (online description of real time monitoring meteorological network in Santa Margarita Ecological Reserve)	May 2008 / La Jolla, CA	D. Cayan
OCEANS 2007 MTS/IEEE	29 Sep-4 Oct 2007 / Vancouver, BC	T. Cook, S.Y. Kim
Odelle Hadley, SIO Grad Student Thesis Defense	May 2008 / La Jolla, CA	D. Cayan
Optimal Control and Management in Biology	12-13 Jun 2008 / Pennsylvania State University, PA	M. Mangel
Pacific Coast Steelhead Management Meeting	4-6 Mar 2008 / Boise, ID	W. Satterthwaite, D. Swank
Pacific Fisheries Management Council, Groundfish Management Team	Nov 2007 / San Diego, CA Jan 2008 / Portland, OR Mar 2008 / Sacramento, CA Apr 2008 / Seattle, WA Jun 2008 / Portland, OR	E. Dick
Pacific Fishery Management Council	Various dates and locations during 2007-2008	M. Mohr
Pacific Salmon Commission Genetic Stock Identification Workshop	12 Sep 2007 / Vancouver, BC	M. Mohr
PACOOS Board of Governors Meeting: "CalCOFI Data"	May 2008 / La Jolla, CA	K. Baker
Partnership on Ocean Global Observations (POGO): "The California Cooperative Oceanic Fisheries Investigations"	Jan 2008 / Bermuda	J.A. Koslow
PI-GOOS Advisory Committee Meeting	Oct 2007 / Nuku'alofa, Tonga	D. Roemmich
Radiowave Operators Working Group (ROWG) workshop	10-14 Sep 2007 / Scripps Institution of Oceanography, La Jolla, CA	E. Terrill, M. Otero, T. Cook, L. Hazard, S. Kim, T. de Paolo
RCM Workshop	Mar 2008 / Trieste, Italy	M. Kanamitsu
Reanalysis Conference	Jan 2008 / Tokyo, Japan	M. Kanamitsu
Riley Lectures at Dalhousie University	Feb 2008 / Halifax, Nova Scotia	L. Levin
RISA Colorado River Basin Modeling Intercomparison meeting	Sep 2007 / La Jolla, CA	D. Cayan
Salmon Aid Festival	1 Jun 2008 / Oakland, CA	H. Fish
San Diego 2050 Steering Committee Meeting	Jun 2008 / La Jolla, CA	D. Cayan
San Diego Environmental Professional (SDEP) Talk	Mar 2008 / La Jolla, CA	D. Cayan
San Diego Foundation, San Diego 2050 Assessment	Sep 2007 / San Diego, CA	D. Cayan
SCOR Workshop	Sep 2007 / Shanghai, China	L. Levin
Scripps Climate Seminar: "Uniform Particle-Droplet Partitioning of 18 Organic and Elemental Components Measured In and Below DYCOMS-II Stratocumulus Clouds"	15 Nov 2007 / UCSD, La Jolla, CA	L.N. Hawkins, L.M. Russell, C.H. Twohy, J.R. Anderson
Sea Grant Interview on Regional Climate Change	Apr 2008 / Davis, CA	D. Cayan
Sea Grant Regional Research Priorities Workshop	18 Sep 2007 / Costa Mesa, CA	S. Peck
Shore to Sea Lecture Series	11 Mar 2008 / Santa Barbara, CA	J. Hildebrand
Shore to Sea Lecture Series	12 Mar 2008 / Ventura, CA	J. Hildebrand
Sierra Nevada Climate Change Symposium (Invited talk)	Dec 2007 / Nevada City, CA	D. Cayan
SIO Advisory Council Meeting	Jan 2008 / La Jolla, CA	D. Cayan
Society for American Archaeology 73 rd Annual Meeting	26-30 Mar 2008 / Vancouver, Canada	C. Boone
Society of Environmental Journalists 17 th Annual Conference	Aug 2007 / Stanford, CA	D. Cayan



South Pacific Applied Geosciences Commission Annual Meeting	Oct 2007 / Nuku'alofa, Tonga	D. Roemmich
STEPS Institute workshop, UCSC	25 Jan 2008 / Santa Cruz, CA	S. Lindley, D. Rundio, T. Williams
Swamp Lake Fieldwork	Sep 2007 / Yosemite Natl Park, CA	D. Cayan
SWAN Workshop (Invited participant)	Dec 2007 / Sacramento, CA	D. Cayan
Symposium on the Ecosystem Approach with Fisheries Acoustics and Complementary Technologies: "The role of acoustics in ecosystem-based management of marine systems"	Jun 2008 / Bergen, Norway	J.A. Koslow
The Systems Biology of Decision Making	16-20 Jun 2008 / Ohio State University, OH	M. Mangel
UC Landels-Hill Big Creek Reserve open house	10 May 2008 / Big Sur, CA	D. Rundio
UCSC 4 th Annual Graduate Research Symposium,	4 Jun 2008 / Santa Cruz, CA	C. Boone
US Argo Science Panel Meeting	Dec 2007 / Washington, DC	D. Roemmich
USCG/OSPR National Preparedness for Response Exercise Program (NPREP) Oil Spill Drill	9-11 Jun 2008 / Convention Center, San Diego, CA	M. Otero, E. Terrill
The Water Center's 18 th Annual Review of Research	14 Feb 2008 / Seattle, WA	E. Rosenberg, A. Steinemann
"Water Resources" talk for UCSD undergraduate Earth Science class	Apr 2008 / La Jolla, CA	D. Cayan
West Coast Salmon Genetic Stock Identification Collaboration workshops	Various dates and locations during 2007-2008	M. Mohr
Western Judges Workshop: "The Relative Magnitude of Natural Climatic Variation and Changes associated with Climate Change"	Nov 2007 / La Jolla, CA	D. Cayan
XBT Fall-rate Workshop	Mar 2008 / Miami, FL	J. Gilson
Yosemite Climate Workshop	Oct 2007 / Yosemite Natl Park, CA	D. Cayan



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Flight	Gate	
FR3916	42	F
FR2372	41	F
FR3002	54	Fi
FR232	53	Fi
FR901	58	Fin
FR434	45	Go
034	55	Go T
9314	48	Go T
03	44	Go T
4	56	Go





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PUBLICATION SUMMARY

	JIMO Lead Author				NOAA Lead Author				Other Lead Author			
	2001-02	2002-03	2003-04	2004-05	2001-02	2002-03	2003-04	2004-05	2001-02	2002-03	2003-04	2004-05
Peer Reviewed	23	24	76	89	2	4	20	20	30	32	30	57
Non Peer Reviewed	56	40	52	62	0	0	12	19	61	41	28	39
	79	64	128	153	2	4	32	39	91	73	58	99

	JIMO Lead Author				NOAA Lead Author				Other Lead Author			
	2005-06	2006-07	2007-08	2008-09	2005-06	2006-07	2007-08	2008-09	2005-06	2006-07	2007-08	2008-09
Peer Reviewed	45	38	45	-	11	10	17	-	32	64	66	-
Non Peer Reviewed	82	48	57	-	20	19	26	-	27	35	85	-
	127	86	102	-	31	29	43	-	59	99	151	-



ACRONYMS

AMLR	Antarctic Marine Living Resources Program
AOML	NOAA/Atlantic Oceanographic and Meteorological Lab
BAS	Birch Aquarium at Scripps
BML	Bodega Marine Laboratory, UC Davis
CA COSEE	California Center for Ocean Science Excellence in Education
CalIT	California Institute of Technology
Caltrans	California Department of Transportation
CAP	California Applications Program
CBNMS	Cordell Banks National Marine Sanctuary
CDFG	California Department of Fish and Game
CEC	California Energy Commission
CEFA	Climate, Ecosystem and Fire Applications
CeNCOOS	Central and Northern California Ocean Observing System
CEOP	Coordinated Enhanced Observing Period
ChESS	Biogeography of Deep-Water Chemosynthetic Ecosystems / Census of Marine Life
CICAR	Cooperative Institute for Climate Applications and Research, Palisades, New York
CICOR	Cooperative Institute for Climate and Ocean Research, Woods Hole, Massachusetts
CICS	Cooperative Institute for Climate Science, Princeton, New Jersey
CIFAR	Cooperative Institute for Arctic Research, Fairbanks, Alaska
CILER	Cooperative Institute for Limnology and Ecosystems Research, Ann Arbor, Michigan
CIMAS	Cooperative Institute for Marine and Atmospheric Studies, Miami, Florida
CIMMS	Cooperative Institute for Mesoscale Meteorological Studies, Norman, Oklahoma
CIMRS	Cooperative Institute for Marine Resource Studies
CIMSS	Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin, Madison
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
CIRA	Cooperative Institute for Research in the Atmosphere
CIRES	Cooperative Institute for Research in Environmental Sciences
CLIMAS	Climate Assessment for the Southwest
CLSA	California Land Surveyors Association
CMER	Cooperative Marine Education and Research
CNES	Centre National d'Etudes Spatiales
COML	Census of Marine Life



COP	NOAA/NOS/Center for Sponsored Coastal Ocean Research/Coastal Ocean Program
CPO	NOAA/Climate Programs Office (formerly, Office of Global Programs (OGP))
CRIP	Centro Regional de Investigacion Pesquera, Instituto Nacional de la Pesca, Ensenada/La Paz, Mexico
CRTN	California Real Time Network
CSIRO	Commonwealth Scientific and Industrial Research Organisation--Australia
CSRC	California Spatial Reference Center
CTD	Conductivity Temperature and Depth (as in, Underway CTD)
DBCP	Data Buoy Cooperation Panel, WMO-IOC
DOE	U.S. Department of Energy
DWR	California Department of Water Resources
ECCO	SIO's Estimating the Circulation and Climate of Oceans Consortium
ENSO	El Niño and Southern Oscillation
ESRL	NOAA/Earth System Research Laboratory
FKNMS	NOAA/Florida Keys National Marine Sanctuary
GACC	Geographic Area Coordination Centers
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water-cycle Experiment
GIS	Geographic Information Systems
GMD	NOAA/ESRL/Global Monitoring Division
GODAE	Global Ocean Data Assimilation Experiment
GPS	Global Positioning System
GSD	NOAA/ESRL/Global Systems Division
GTS	GNU Triangulated Surface
HRC	Hydrologic Research Center, San Diego, CA
HRX	Repeat high resolution expendable Bathythermograph
ICARTT	International Consortium for Atmospheric Research on Transport and Transformation
IOC	Intergovernmental Oceanographic Commission
IOOS	Integrated and Sustained Ocean Observations
IRD	Institut de Recherche pour le Développement
IRI	International Research Institute for Climate Prediction
JCOMM	Joint WMO-10C Technical Commission for Oceanography and Marine Meteorology
JIMAR	Joint Institute for Marine and Atmospheric Research
JIMO	Joint Institute for Marine Observations
JISAO	Joint Institute for the Study of Atmosphere and Ocean
JPL	Jet Propulsion Laboratory, NASA



MBARI	Monterey Bay Aquarium Research Institute
MIT	Massachusetts Institute of Technology, Harvard
MPI	Max Planck Institute, Germany
MPL	Marine Physical Laboratory, SIO, UCSD
NASA	National Aeronautics and Space Administration
NDBC	NOAA/NWS/National Data Buoy Center
NCAR	National Center for Atmospheric Research
NCEP	NOAA/National Centers for Environmental Predictions
NEFSC	NOAA/Northeast Fisheries Science Center
NESDIS	NOAA/National Environmental Satellite, Data, and Information Services
NGI	Northern Gulf Institute
NGS	NOAA/National Geodetic Survey
NIWA	National Institute of Water and Atmospheric Research, New Zealand
NMFS	NOAA/National Marine Fisheries Service
NMSP	National Marine Sanctuary Program
NOS	NOAA/National Ocean Service
NSF	National Science Foundation
NWFSC	NOAA/Northwest Fisheries Science Center, NMFS
NWS	NOAA/National Weather Service
OAR	NOAA/Ocean and Atmospheric Research
OE	NOAA/Office of Ocean Exploration
OGCM	Oceanic General Circulation Model
OGP	See CPO
ONR	Office of Naval Research
ORA	NOAA/Office of Research and Applications
PDO	Pacific Decadal Oscillation
PFEG	NOAA/NMFS/Pacific Fisheries Environmental Group
PIFSC	NOAA/NMFS/Pacific Islands Fisheries Science Center
PMEL	NOAA/Pacific Marine Environment Lab
R/V	Research Vessel
ROWG	Radio Operators Working Group
SAS	Simplified Arakawa-Schubert cumulus convection scheme
SCCWRP	Southern California Coastal Water Research Project
SDG&E	San Diego Gas & Electric
SEFSC	NOAA/Southeast Fisheries Science Center, Panama City, FL




SIO	Scripps Institution of Oceanography, UCSD
SOPAC	Scripps Orbit and Permanent Array Center
SST	Sea surface temperature
SVP	Surface Velocity Program
SWFSC	NOAA/Southwest Fisheries Science Center, NMFS
UC	University of California
UCD	University of California, Davis
UCLA	University of California, Los Angeles
UCSB	University of California, Santa Barbara
UCSC	University of California, Santa Cruz
UCSD	University of California, San Diego
UNAM	Universidad Nacional Autonoma de Mexico
USARP	U.S. Antarctic Research Program
USC	University of Southern California
USFS	U.S. Fire Service
USGS	U.S. Geological Survey
UW	University of Washington, Seattle
VAdm	Vice Admiral
VOS	Voluntary Observing Ship
WECC	Western Electricity Coordinating Council
WHOI	Woods Hole Oceanographic Institution
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity Temperature and Depth

Credits

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